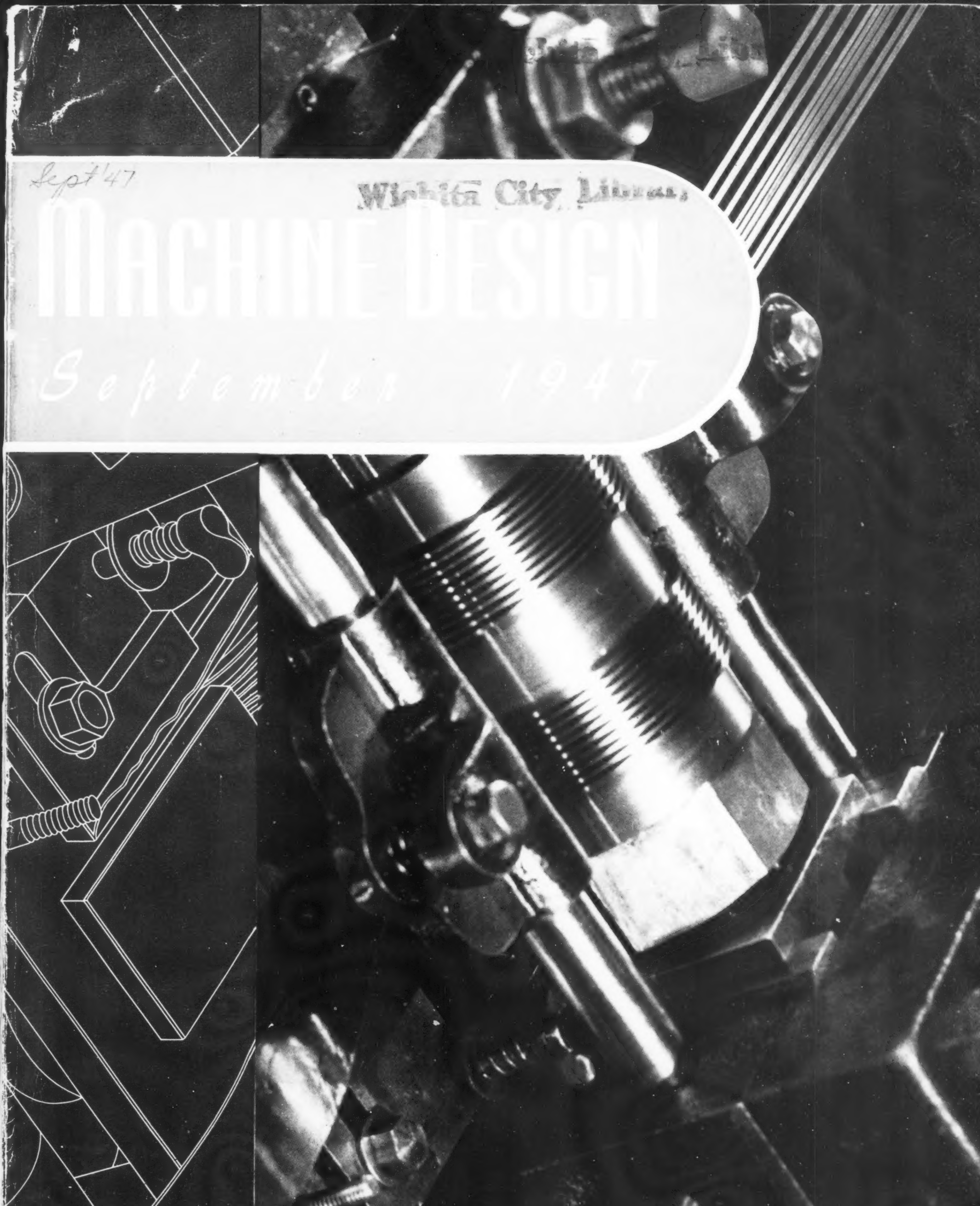
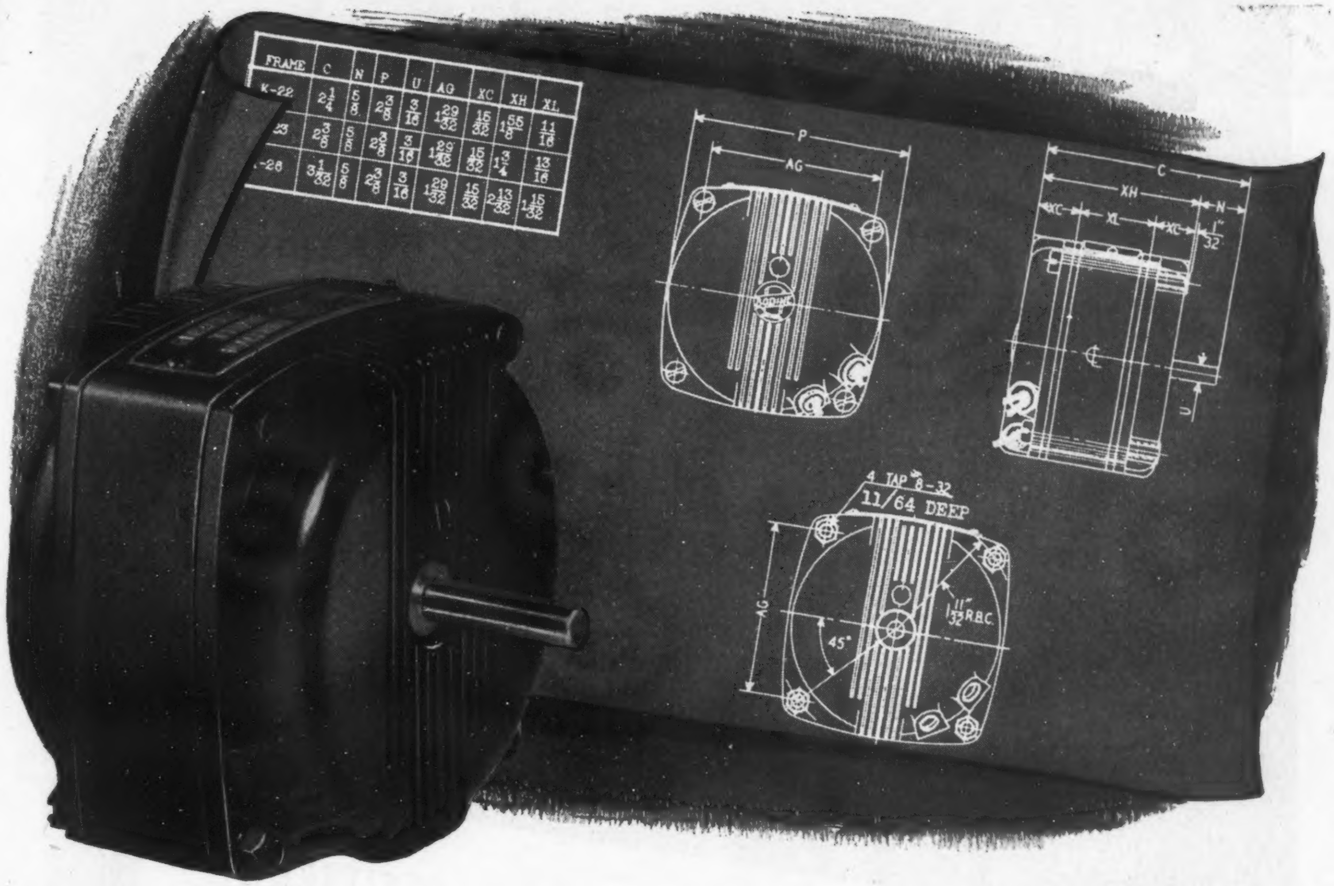
MACHINE DESIGN

September 1947



In This Issue: QUICK-ACTING LATCH RELEASES
POWDER METAL PARTS . . . PILOTLESS FLIGHT



Here's a motor for YOUR APPLICATION

If you need a motor for timing, chart drive, or similar low-power application, fit this motor into your plan. The Bodine Type K Motor is ideal for many such hard-to-get-at installations because of its compact design and extreme dependability. It has distributed windings and ball bearings for versatility of application. Either synchronous or nonsynchronous types are available, with or without integral speed reducers, in ranges from 1/750 to 1/2000 hp.

CAREFUL WORKMANSHIP

All Bodine motors are carefully constructed to high quality standards throughout. Operating parts of these motors are designed to provide long life with a minimum of attention.

WIDE VARIETY

Bodine motors and speed reducer motors are available in over 3000 standard specifications to meet the needs of product designers and engineers. They have provided designers with a dependable source of operating power for over forty years. Bodine Electric Company, 2258 W. Ohio St., Chicago, Ill.

TYPICAL APPLICATION

Brenkert Radarc Lamp, manufactured by Brenkert Light Projection Company, Detroit, Michigan.

The Brenkert Radarc Projection Lamp is used as a light source for the projection of motion pictures in theatres where the carbon arc is employed. The Radarc is the newest design in a series of such lamps which have used Bodine motors for over twenty years to provide proper movement of the carbons which produce the arc light.

BODINE FRACTIONAL HORSEPOWER MOTORS

MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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Published by The Penton Publishing Co. E. L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres. and Gen. Mgr.; R. C. Jaenke, Vice Pres.; F. G. Steinebach, Vice Pres. and Secy.; E. L. Werner, Asst. Treas. Published on the seventh of each month.

This Month's Cover: Slitter used in the production of mainsprings for watches. The machine cuts alloy strip into proper widths for mainsprings. Because of the extreme hardness of the alloy, perfected by the Elgin National Watch Co., special equipment was designed to process it.

CONTENTS

September, 1947 — **Vol. 19, Number 9**

What things do *you* think of when we say "aluminum"?

When asked that question in a recent survey, 92% of the people interviewed replied: "Pots and pans."

On the other hand, *less than 4%* mentioned such aluminum "naturals" as roofing and siding, heating and ventilating equipment, gutters and down-spouts, busses, garage doors, garden tools, home-trailers.

What does this mean?

Simply that while aluminum has proved itself the successor of other metals in hundreds of applications . . . public awareness has largely remained at the pot-and-pan level.

And without awareness, how can there be *demand?*

To increase consumer awareness of aluminum products . . . to interpret them in terms of *better living* and thus create demand . . . is the objective of the above advertisement and the many that will follow.

They will appear, in full color, in such top-read magazines as Saturday Evening Post, Newsweek, Collier's, Time, Sunset, reaching a total audience of over 30 million every month! Such advertising, we believe, is bound to influence the buying habits of a big share of this audience.

Which will mean a lot more business for the makers of aluminum products.

Ready to serve you—*today*...

Kaiser Aluminum

a Permanente Metals product

DISTRIBUTED BY PERMANENTE PRODUCTS COMPANY, KAISER BLDG., OAKLAND, CALIFORNIA . . . WITH OFFICES IN:
Seattle, Wash. Oakland, Calif. Los Angeles, Calif. Dallas, Texas Wichita, Kan. Kansas City, Mo. St. Louis, Mo. Atlanta, Ga. Minneapolis, Minn. Milwaukee, Wis. Chicago, Ill. Cincinnati, Ohio Cleveland, Ohio Detroit, Mich. Boston, Mass. Hartford, Conn. Buffalo, N. Y. New York City, N. Y. Philadelphia, Penn. Washington, D. C.

Itemized Index

Classified for convenience when studying specific design problems

MACHINE DESIGN is indexed in Industrial Arts Index and Engineering Index Service, both available in libraries generally.

10 TYPES OF OZALID PRINTS

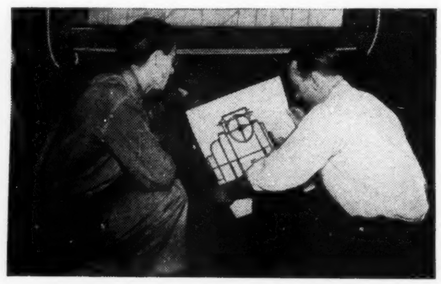
and how you save by using them:

With a new Ozalid Streamliner you do jobs far beyond the scope of any other reproduction process.

Also, routine work is copied more efficiently because you always get a positive print from your original—on the type of Ozalid material you prefer.

You have a choice of 10 types of prints instead of 1 because OZALID employs a DRY DEVELOPMENT technique which greatly simplifies printmaking . . . permits use of a variety of sensitized papers, cloths, foils, and films—all of which you process exactly the same, in seconds.

Here are the ten Ozalid "types" and some ways in which you'll save time, labor, and material by using them:



1. OZALID BLACK-LINE

2. OZALID BLUE-LINE

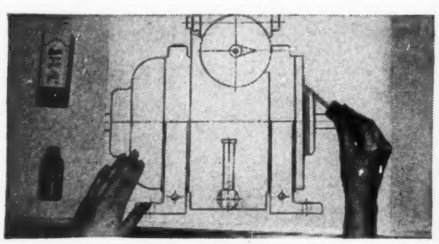
3. OZALID RED-LINE

➡

For routine prints in the drafting room, shop, or office.

Anything drawn, typed, or printed on translucent material is reproduced with sharp, easy-to-read images on a white background.

By assigning identifying colors, you can distinguish prints of different departments... recognize checked from unchecked prints, etc.

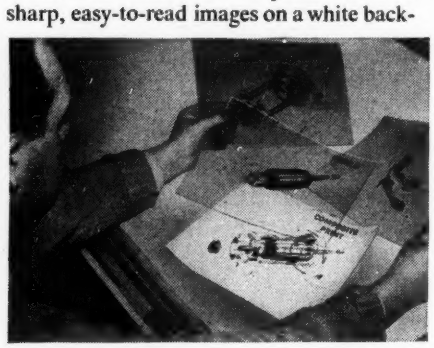


4. OZALID SEPIA-LINE

5. OZALID DOUBLE-COATED SEPIA

6. OZALID TRANSLUCENT CLOTH

For "intermediates" which may be substituted for originals in subsequent print production. Important savings in time and labor are realized when design changes are necessary: Obsolete lines are removed with Ozalid Corrector Fluid; changes drawn in and required number of prints made from "new" masters.



7. OZALID FOIL

For composite prints: Details are printed on individual foils . . . and overlaid to produce a print showing separate details in relation to each other.

Ozalid Foil also produces faster-printing intermediates from old or worn originals, since it intensifies line detail.

8. OZALID CHARTFILM

For lustrous black-line reproductions on white plastic base, ideal for wiring diagrams, instrument panels, etc. No protective covering is needed; can be cleaned with a damp cloth.

9. OZALID OPAQUE CLOTH

For extremely durable prints for shop use, files, etc.

10. OZALID DRYPHOTO

For almost instantaneous, high-quality reproductions of any photographic subject—in sepia, black, blue, or two-tone effect.

Produce them from film positives (as illustrated above), which can be made from any of your negatives. Keep on file. Use when desired.

Gentlemen: Dept. 85
Please send free Ozalid Streamliner booklet 321 and the 10 types of Ozalid prints.

Name__________

Position__________

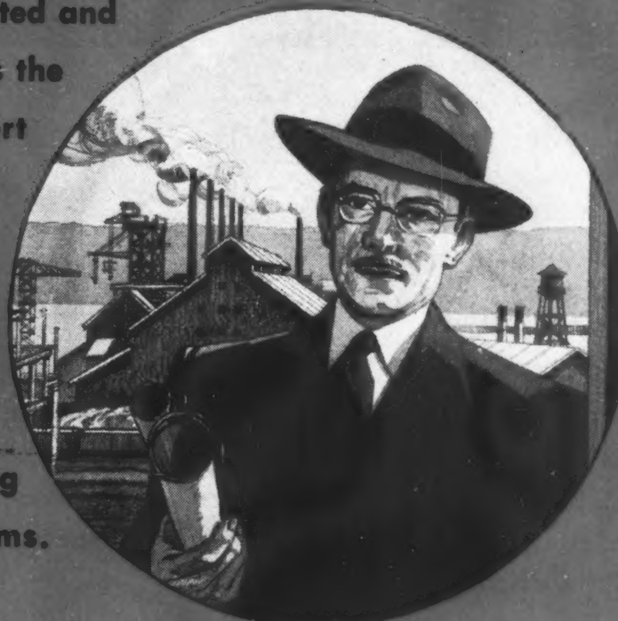
Company__________

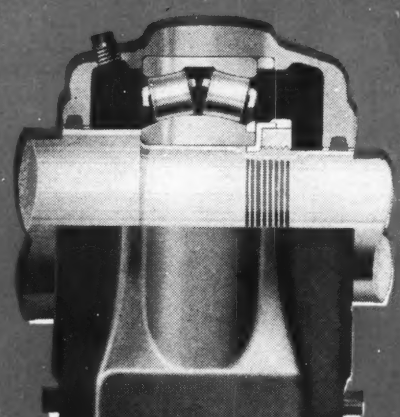
Address__________

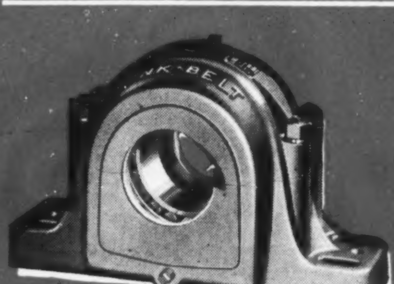
OZALID

Division of
General Aniline and Film Corporation
Johnson City, New York
Ozalid in Canada
Hughes Owens Co., Ltd., Montreal

To claim long life—to claim efficiency—to claim accuracy for Link-Belt Ball and Roller Bearings is merely to accent the obvious. More interesting to you is the completeness of Link-Belt's Ball and Roller Bearing line—mounted and unmounted. Still more interesting is the nation-wide organization of expert Link-Belt Bearing Engineers, whose sole service to Link-Belt rests *in their service to you.* Use our books (No. 2094 and 2095 sent immediately upon request)... but use also the expert knowledge of our Bearing Engineers on your design problems.







1 Heavy series precision-built double row self-aligning roller bearings.

2 Inner ring directly mounted on precision turned or ground shafting assures greatest accuracy.

3 Locknut clamps assembly securely to shaft and is prevented from loosening by serrated lock washer.

4 Felt seals for grease lubrication or "Spiro-Seals" for oil or grease lubrication.

5 True flat surfaces assured for nut pressure surface.

6 Housings drilled and tapped for drain plugs on both sides.

7 Casting spotted for dowel holes to locate unit on support. Slotted holes for foundation bolts.

8 Sturdy, compact, split housing provides convenience in mounting, lubrication and disassembly.

9 Tapped holes in cap take standard screw to raise cap off base without damage to finished surface.

10 Permits different methods of lubrication, such as grease, constant level oil or circulating oil.

11 Bearings can be fixed or floated axially. "C" spacers may be inserted or removed as required.

LINK-BELT COMPANY
Chicago 9 • Indianapolis 6 • Philadelphia 40
Atlanta • Dallas 1 • Minneapolis 5 • San Francisco 24
Los Angeles 33 • Seattle 4 • Toronto 8 • Offices, Factory Branch Stores and Distributors in Principal Cities.

LINK-BELT

BALL AND ROLLER BEARINGS

VISIT OUR EXHIBIT—NATIONAL MACHINE TOOL SHOW—CHICAGO, SEPTEMBER 16-17—BOOTH 652

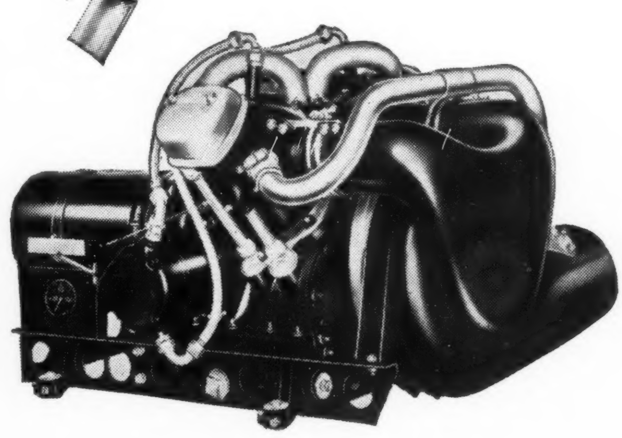
YOU CAN SAVE MAN-HOURS

with this Stainless Tubing . . .

Your first saving is in easy, low cost fabrication because of the *uniform walls* of Carpenter Stainless Tubing. Bending, flanging, flaring, welding, etc. can be done quickly and safely.

This Tubing keeps equipment and parts on the job longer, with less time for replacement and repair. For with Carpenter Stainless Tubing you get *more than standard analysis.* We can provide special finishes for extra protection against corrosion and contamination . . . or even special analyses when needed.

To get the most from every dollar you invest in Stainless Tubing, make use of Carpenter's 20 years of experience with Stainless Pipe and Tube. Drop us a line about your specific problems.



SELECTION, FABRICATION and USE

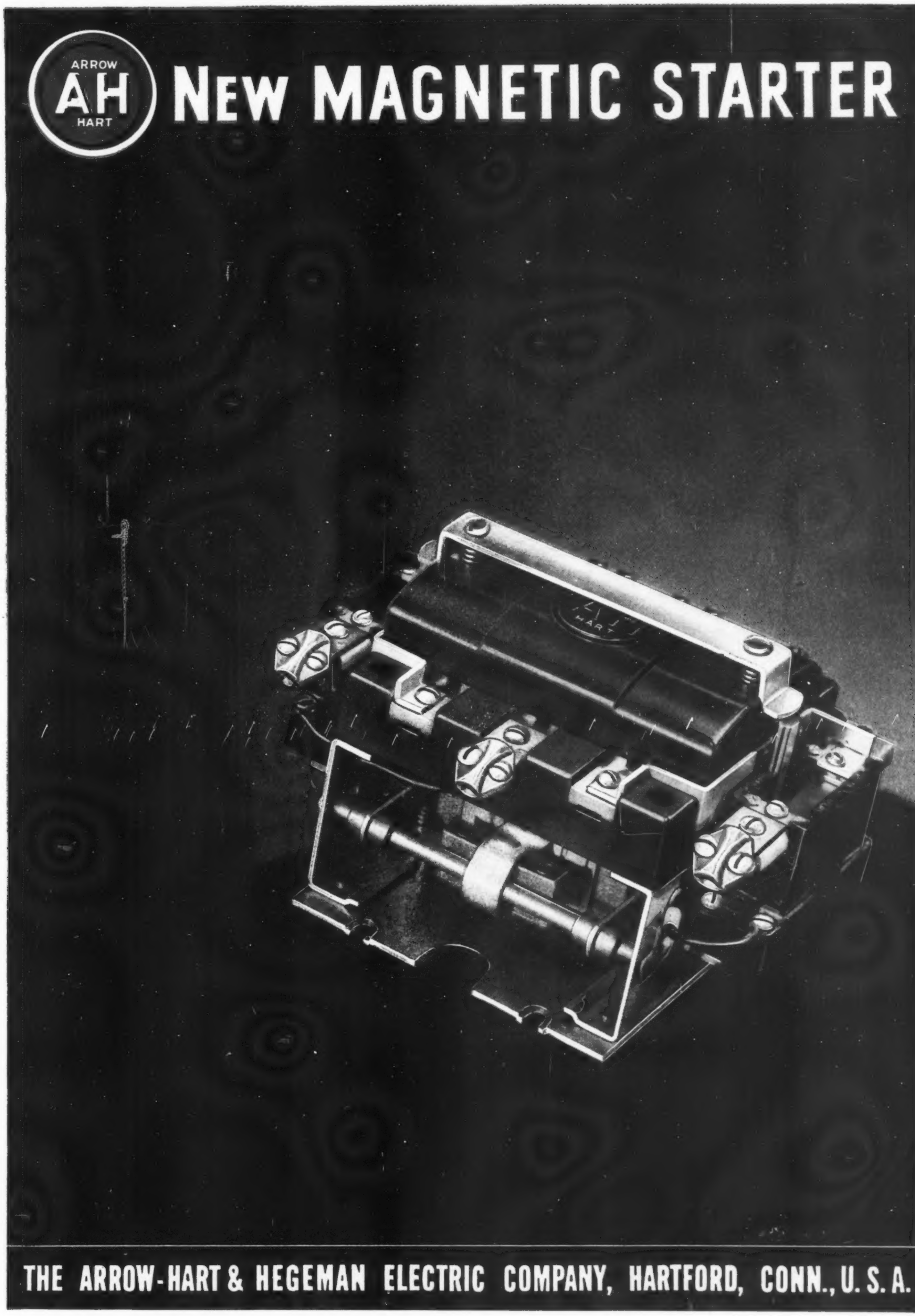
To help you make full use of the properties of Stainless Tubing and fabricate it, the new Carpenter Stainless Tubing Data Book is available to Engineering and Management executives. A note on your company letterhead will bring a copy to you.

THE CARPENTER STEEL COMPANY
Alloy Tube Division • 115 Springfield Road, Union, N. J.

Carpenter

STAINLESS TUBING

"MORE THAN CORROSION RESISTANCE"


ARROW
AH
HART
NEW MAGNETIC STARTER
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.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Scientifically
PROOF OF SUPERIORITY
Approximately 90% of the MACHINE TOOL BUILDERS who will exhibit at THE MACHINE TOOL SHOW use GITS Oilers, Oil and Grease Seals and Lubricating Devices
GITS BROS. MFG. CO.
1868 SO. KILBOURN AVE., CHICAGO 23, ILL.
Visit us at
Booth 405
MACHINE TOOL SHOW
CHICAGO, SEPT. 17-26, 1947


MODERN METHODS, IN MODERN...
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That's B-Line
TRULY LIFE-TIME MOTORS
B-LINE
COPYRIGHT 1947 THE BROWN-BROCKMEYER CO.
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1/6 to 30 HP
B-LINE GEARMOTORS
All Standard and Special Ratios
TOOLMASTER
Electric Grinders
Pedestal & Bench
Write for
MOTOR AND GEARMOTOR BULLETIN 5000
ELECTRIC GRINDER BULLETIN 7000
THE BROWN-BROCKMEYER COMPANY
PLANTS AT DAYTON, WILMINGTON, WASHINGTON AND XENIA, OHIO
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BOOTH
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Dodge—Chicago Plant
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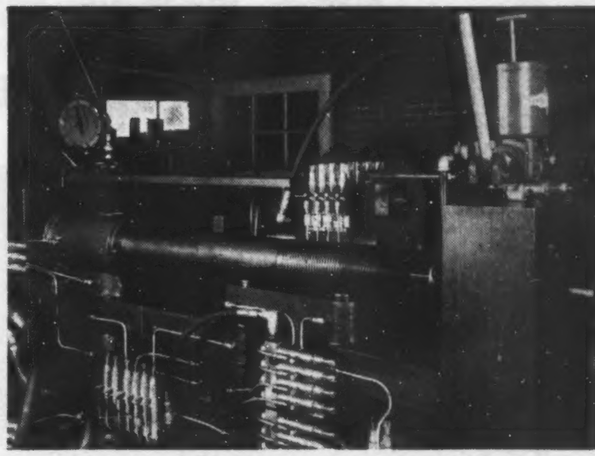
Arbors, Collets and Adapters
Screw Machine Tools
Permanent Magnet Chucks
Vises
Pumps
Other Useful Shop Equipment
BROWN &

Mass Lubrication for Mass Production

made easy with

LINCOLN



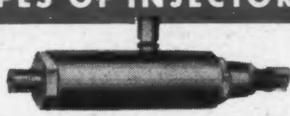
A Lincoln Centro-Matic System on a Die Casting Machine.

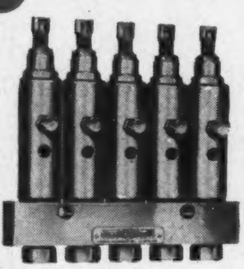
CENTRO-MATIC LUBRICATING SYSTEMS

Specifically engineered for flexibility of application, simplicity of installation, and dependable operation, these *single line* centralized lubricating systems deliver oil or grease to bearings by positive displacement, under line pressure, providing greatest assurance of proper lubrication—in seconds instead of hours. All that is required is a Centro-Matic Injector for each bearing, arranged singly or in manifold, and connected by only a *single lubricant line* to a Centro-Matic Lubricant Pump. Illustrated below are the various types of injectors, pumping units and accessories from which a selection can be made to meet the particular requirements of a single machine or a battery of machines.

You can give added sales appeal and top operating efficiency to the machine tools and industrial equipment you manufacture by including Lincoln Centro-Matic Lubricating Systems.

TYPES OF INJECTORS...





LINCOLN SERIES SL-1 INJECTORS

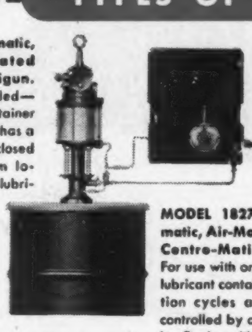
Available in two types, the No. 81713 for individual mounting and the No. 81713A for mounting in manifold. Injectors will handle lubricants ranging from machine oils to fibrous greases. Lubricant output adjustable up to .04 ozs. Units include External Adjusting Nut, Indicator Stem, and Fitting for initial filling of feeder line and visible check on quantity of lubricant discharged. Manifold assemblies are available with from 2 to 5 injectors, and may be mounted vertically or horizontally. Any combination of manifold units may be connected in series or mounted one above the other.

LINCOLN SERIES SL-3 INJECTORS

Compact, space-saving design of the Series SL-3 Injectors makes them especially desirable when mounting space is limited. Injectors in manifolds of two, three and four units are provided where conditions favor group mounting. Discharge of Injectors is by positive displacement. Units include Adjusting Knob with spring clip-lock and Indicator Stem. SL-3 Injectors may be mounted vertically or horizontally, and any combination of same can be connected in series, as with the SL-1 Injector. Lubricant output adjustable up to .004 ozs.

TYPES OF PUMPING UNITS...

MODEL 1825 Automatic, Air-Motor Operated Centro-Matic Lubrigun. Automatically controlled—manually timed. Container capacity 60-lbs. Unit has a compact, totally-enclosed pumping mechanism located beneath the lubricant container.

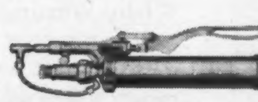


MODEL 1827 Full Automatic, Air-Motor Operated Centro-Matic Lubrigun. For use with original 400-lb. lubricant containers. Lubrication cycles automatically controlled by automatic Timing Device with signal alarm.

MODEL 1840 Full Automatic, Electric-Motor Operated Centro-Matic Lubrigun. Lubrication cycles automatically controlled by Timing Device. Motor—110 Volts A. C. 60 cycle, single phase. Container capacity 30 lbs.

MODEL 1806 Manually Operated Centro-Matic Lubrigun. Capacity 10-lbs. Has large button head fitting for attaching Filler Pump Hose.

MODEL 1805 Manually Operated Centro-Matic Lubrigun. Capacity 2-lbs. Has large button head fitting for attaching Filler Pump Hose.



MODEL 1807 Portable, Manually Operated Centro-Matic Lubrigun. Capacity 1-lb. Spring Primed. Unit includes 18" Whip Hose Assembly.

ACCESSORIES...

A complete line of installation accessories—copper tubing, high pressure, flexible lubricant hose, fittings, clips and everything needed to make the installation are available.

Write for Bulletin...

Mail coupon for your copy of illustrated Bulletin No. 801. It gives you full information on the newest developments in Centralized Lubrication. Our lubrication engineers are ready to assist you in solving your lubricating equipment problems. We invite you to make use of this service.

LINCOLN

Pioneer Builders of Engineered Lubricating Equipment

LINCOLN ENGINEERING COMPANY • ST. LOUIS 20, MO.

Please give me information on Centro-Matic Systems for (type of machine)__________. Send me your new Centro-Matic Bulletin 801 ☐ Catalog on Industrial Lubricating Equipment. ☐

Name__________

Title__________

Company__________

Address__________

City__________ State__________

MD B47-16A

The most important advance in motor design in 58 YEARS...

★ **STANDARD INTEGRAL MOTORS, FRAMES 326 TO 203, NOW AVAILABLE FROM STOCK**

When Westinghouse engineers began designing a postwar motor they abandoned the concept that all motors must be cousins. Instead, they asked electric motor users *what they wanted* in motors . . . features they couldn't buy in any one motor.

These features demanded most by motor users are *all* incorporated in the new Life-Line Motors:

ALL-STEEL PROTECTION. All frames, feet and brackets are HEAVY STEEL. Life-Line Motor stators are far stronger—a new core locking device eliminates rivets.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Dayton Multiple V-Belt Drive transmits power to sand conditioning blade

Drudgery of sand conditioning—the painfully slow method of shoveling—has been replaced by a modern, mechanized method. Now, a lawn mower type, cutting blade cylinder does the work easily, more uniformly. For fast, smooth and dependable power flow the designer specified a Dayton V-Belt Drive. And, as a result, uniform sand conditioning increases foundry production of better castings . . . at less cost per unit.

This is another of the many examples of the flexibility of Dayton V-Belt Drives. The capacity of Dayton V-Belt Drives to perform in excess of standard requirements—under all operating conditions—is another of the many reasons more industrial designers *consistently* specify *Daytons* for original equipment. A Dayton Power Transmission Specialist is ready to help you. Call or write: DAYTON RUBBER · DAYTON, OHIO.

NOW! **Rayon Cords*

PROVIDE DAYTON V-BELTS WITH

1. Minimum Stretch 2. Greater Flex Strength 3. Longer V-Belt Life

*Rayon cords are *specially processed* by Dayton for use in V-Belts to provide the most efficient and economical power transmission service for your machine needs. For the complete story write for booklet A-469.

Dayton Rubber

THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

THE WORLD'S LARGEST MANUFACTURER OF V-BELTS

JUST A FEW *Pleasant* SECONDS TO MAKE BRUNING BLACK AND WHITE PRINTS!

Bruning Model 91 Volumatic Printer-Developer for large volume production.

Bruning Model 2 BW—Copyflex Printer with Model 153M BW Developer for small volume production.

When you choose a process for making direct-line prints, be sure to get one that your operators will *like* to use. The Bruning BW Process keeps operators working at top-notch efficiency. That's because Bruning BW machines have no confusing gadgets to create mistakes and spoil work. And, of course, you need no plumbing connections for Bruning BW equipment—no ducts for dispelling unpleasant fumes. You can put it *anywhere* in the drafting room, engineering department or private office.

AMAZING VERSATILITY! With the Bruning BW process, you can have prints either on cut sheets or roll stock—in amazing variety! For example, Bruning BW Prints can be made with black or colored lines on white backgrounds, or with black or colored lines on green or pink tinted backgrounds. BW Prints also can be made on card-weight or extra thin paper, on cloth or on transparent paper.

PHOTOGRAPHIC PRINTS, TOO! Bruning BW machines may also be used to produce photographic prints—making it possible to duplicate anything drawn, typed, printed or illustrated, as well as to make BW Prints. With the use of Copyflex materials, Bruning machines copy tracings, line drawings, specifications, Van Dyke negatives, blue prints, etc. Original material with copy on both sides can be reproduced from either side or both sides.

GET ALL THE FACTS ABOUT BW. Find out for yourself why so many users prefer to make direct process black line prints the simple, easy and pleasant way with the Bruning BW process. The coupon will bring you full information!

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Gentlemen: I want to know more about Bruning BW Prints and equipment. Please send me information.

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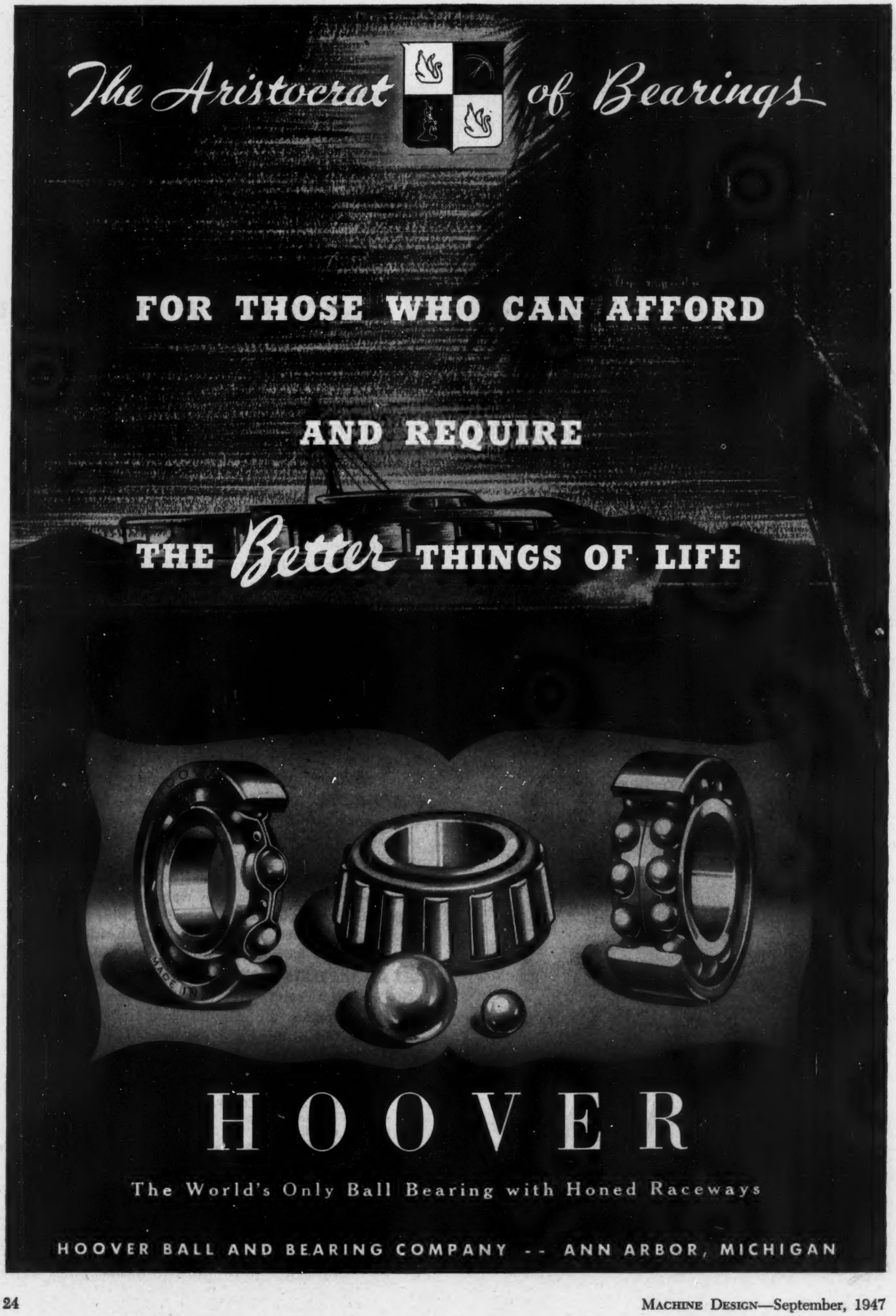
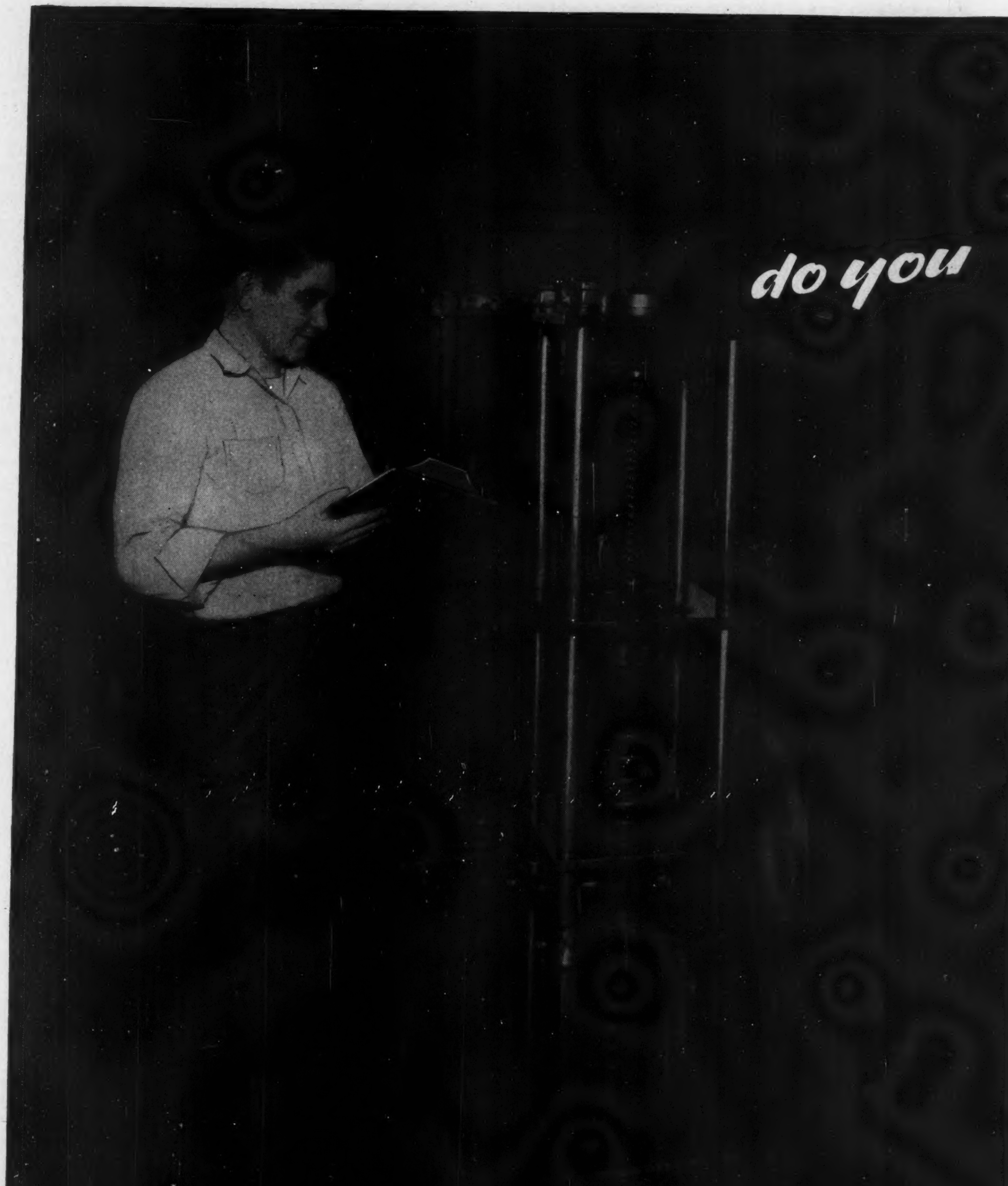


The Aristocrat of Bearings
FOR THOSE WHO CAN AFFORD
AND REQUIRE
THE Better THINGS OF LIFE
HOOVER
The World's Only Ball Bearing with Honed Raceways
HOOVER BALL AND BEARING COMPANY -- ANN ARBOR, MICHIGAN


do you

ELECTROL PRODUCTS
—IN STOCK OR MADE TO ORDER—
FOR EVERY INDUSTRIAL NEED

Back of ELECTROL'S CYLINDERS for industry is the experience acquired in manufacturing *more than a quarter-of-a-million cylinders* for military and civilian aircraft. This "know how" applied in making industrial cylinders means a lot. It goes into every cylinder you buy whether it is a stock model or a made-to-order job.

ELECTROL CHECK VALVES are available for every type of system. Stock valves meet many requirements. Special designs are made to fill unusual demands.

Whether it is a cylinder or a check valve, *it has to be good to carry* ELECTROL'S name.

WRITE TODAY! ELECTROL ENGINEERS will cooperate with you regarding your hydraulic requirements.

ELECTROL INCORPORATED

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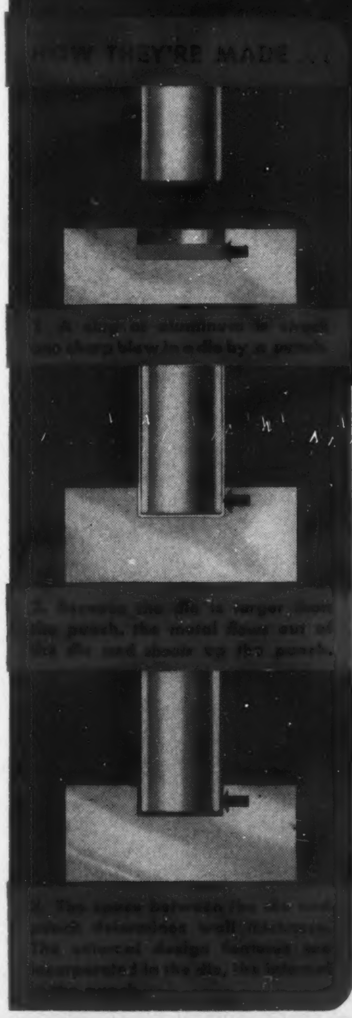
CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES • CHECK VALVES RELIEF VALVES • HAND PUMPS • POWERPAKS LANDING GEAR OLEOS SOLENOID VALVES ON-OFF VALVES • SERVO CYLINDERS • TRANSFER VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES



They're ALCOA Impact Extrusions

These parts show you four of the many special designs that can be made by the impact extrusion process. In the wink of an eye a slug of Alcoa Aluminum is walloped once—impact-extruded—to form the bodies of each of these parts. Then minor flanging and threading operations complete the jobs.

Almost any symmetrical shell —round, oval, or square—can be made quicker, with much greater leeway in special design features, and at lower cost by the impact extrusion process.

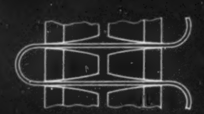
ALUMINUM COMPANY OF AMERICA, 1940 Gulf Building, Pittsburgh 19, Pennsylvania. Sales offices in leading cities.

MORE people want MORE aluminum for MORE uses than ever

ALCOA FIRST IN ALUMINUM

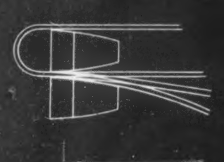
IN EVERY COMMERCIAL FORM

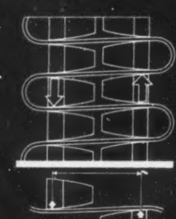
HOW FALK STEELFLEX COUPLINGS WORK



1. Grooves, in a precise arc, and with a radius and length proportional to the capacity of the coupling, are cut into two identical hubs of moderately high carbon steel—forged of Falk alloy cast steel.

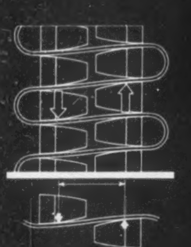
2. These grooves provide a slot for a grid member made of chrome alloy steel with an elastic limit of 180,000 pounds per square inch and an ultimate strength of 220,000 pounds per square inch.

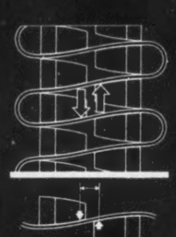




3. This grid fits snugly into the curved grooves cut into the hubs of the coupling. The grooves provide a scientifically cut bearing surface for the grid. This bearing surface extends from the outer to the inner edge of the grooves. The grid bears on the grooves in proportion to the load.

4. Under light loads, the grid bears only at the outer edges of the grooves. This permits a long, free, elastic span between the outer edges of both hubs. Power is transmitted through almost the entire length of the grid rung.



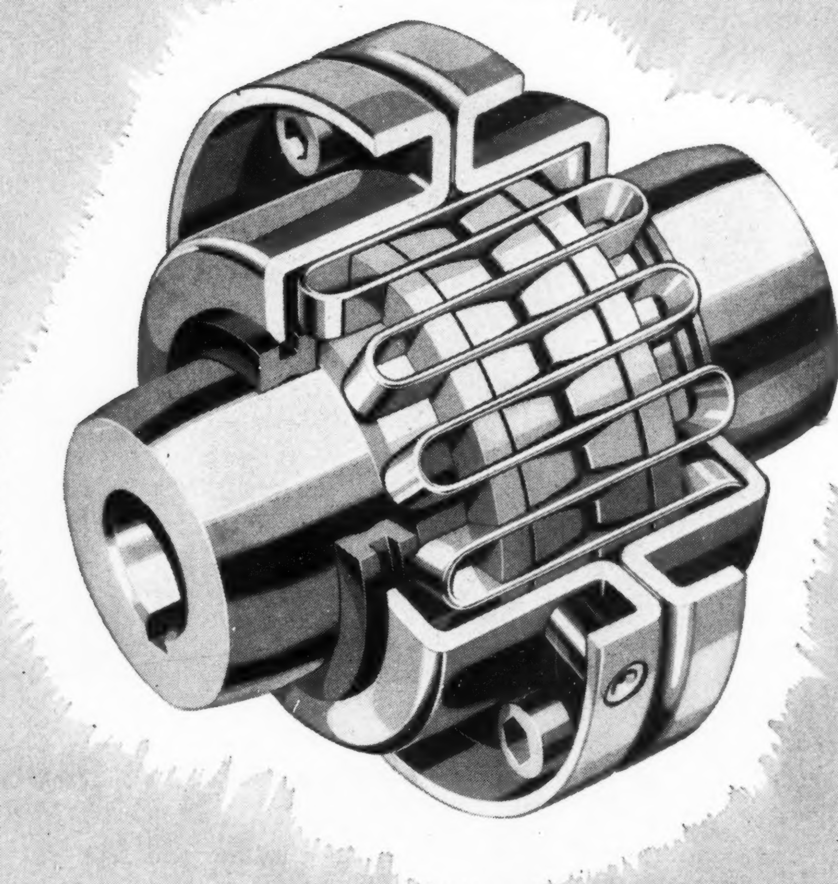


5. Under normal loads, the grid bears on a larger area of the grid grooves and the span of the grid run is shortened. It transmits more power and maintains its capacity to absorb shocks and dampen vibration.

6. Under peak loads, the grid rungs bear over almost all of the curved surfaces of the grooves. The span of the grid rung becomes very short. Under the impact of shock loads the grid flexes and continues to transmit power smoothly.

Falk gives you, in the Steelflex Coupling, a plus-value coupling. Through the grid-groove design, the Falk Coupling transmits power with minimum loss because of angular and parallel misalignment, and with free end float where desired. At the same time it provides torsional resilience that absorbs shocks, dampens vibration, and cushions even severe peak loads.

Why it <u>costs</u> to buy and



FALK Steelflex Couplings offer proved economy

No other coupling has *all three* advantages which combine to lower your total coupling costs

1. **Torsional Resilience:** This ability to spread the peak of shock loads over a longer time reduces stresses in your connected machinery. It is provided by the Falk Steelflex grid-groove design.
2. **Flexibility:** The all-steel construction of the Falk Steelflex Coupling assures greater flexibility in actual service . . . and prolongs the working life of connected machinery.
3. **One Type for Most Uses:** Improvements in design make it possible to meet practically all industrial installation requirements. This fact facilitates buying, replacing, or servicing couplings promptly.

PERMITE Permanent Mold ALUMINUM CASTINGS

Help keep labor costs DOWN!

Clean, sleek castings — often requiring no machining operations, and never more than a minimum . . . Castings made to tolerances as close as $\pm$ .010" . . . Castings of finer grain structures, greater strength and hardness, consistent uniformity.

Such are aluminum alloy castings made by the Permite Permanent Mold process. They're advanced, modern castings that step up profits by reducing finishing operations and helping hold labor costs to a minimum.

With Permite Castings you can machine the full run of a part well within the tolerance, without tool resetting. And the greater tensile strength of these "precision-made" castings frequently permits thinner cross-sections, reducing weight and cost.

It will pay you to investigate the cost-cutting possibilities of Permite Permanent Mold Aluminum Castings for your products. Submit blueprints for recommendations and quotations.

PERMITE

ALUMINUM INDUSTRIES, INC.

CINCINNATI 25, OHIO

DETROIT: 809 New Center Building. NEW YORK: 9 Rockefeller Plaza. CHICAGO: 64 E. Jackson Boulevard. ATLANTA: 413 Grant Building

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS


For over 40 years we have been developing special motors for special jobs—our engineering department has a wealth of experience along this line — it is at your disposal.
No matter what your electrical motor problem or requirements—we believe our engineering department can serve you to your advantage. We earnestly solicit your inquiries.
The LOUIS ALLIS Co.
Milwaukee 7, Wis.

Designer's

NOW

an adjustable-speed a-c motor with TRI/CLAD EXTRA PROTECTION

REG. U.S. PAT. OFF.

Here's a new motor that gives you all the advantages of an adjustable-speed drive PLUS the strength and extra protection of Tri-Clad construction. It's the General Electric Type ACA adjustable-speed Tri-Clad induction motor. Designed for use on machines where a 3-to-1 speed range is satisfactory, this new motor is simple in construction and is provided with finger-tip speed-changing control. Constant torque is available over the entire speed range. This new General Electric motor will be on exhibit at the Machine Tool Show.

IMPORTANT FACTS ABOUT THIS NEW TRI/CLAD MOTOR

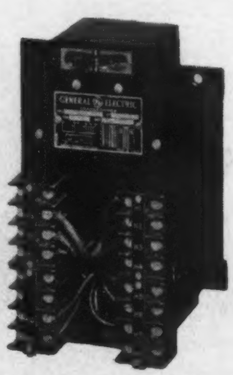
SPEED RANGE: Infinitely adjustable over a 3-to-1 range by simply turning a knob.

HORSEPOWER RATINGS: From 3 up to 50 hp. Inquire about larger ratings.

CONSTRUCTION: Famous Tri-Clad construction features protect this motor against electrical breakdown, operating wear and tear, and physical damage.

WHAT DO *YOU* WANT IN A MACHINE-TOOL TRANSFORMER?

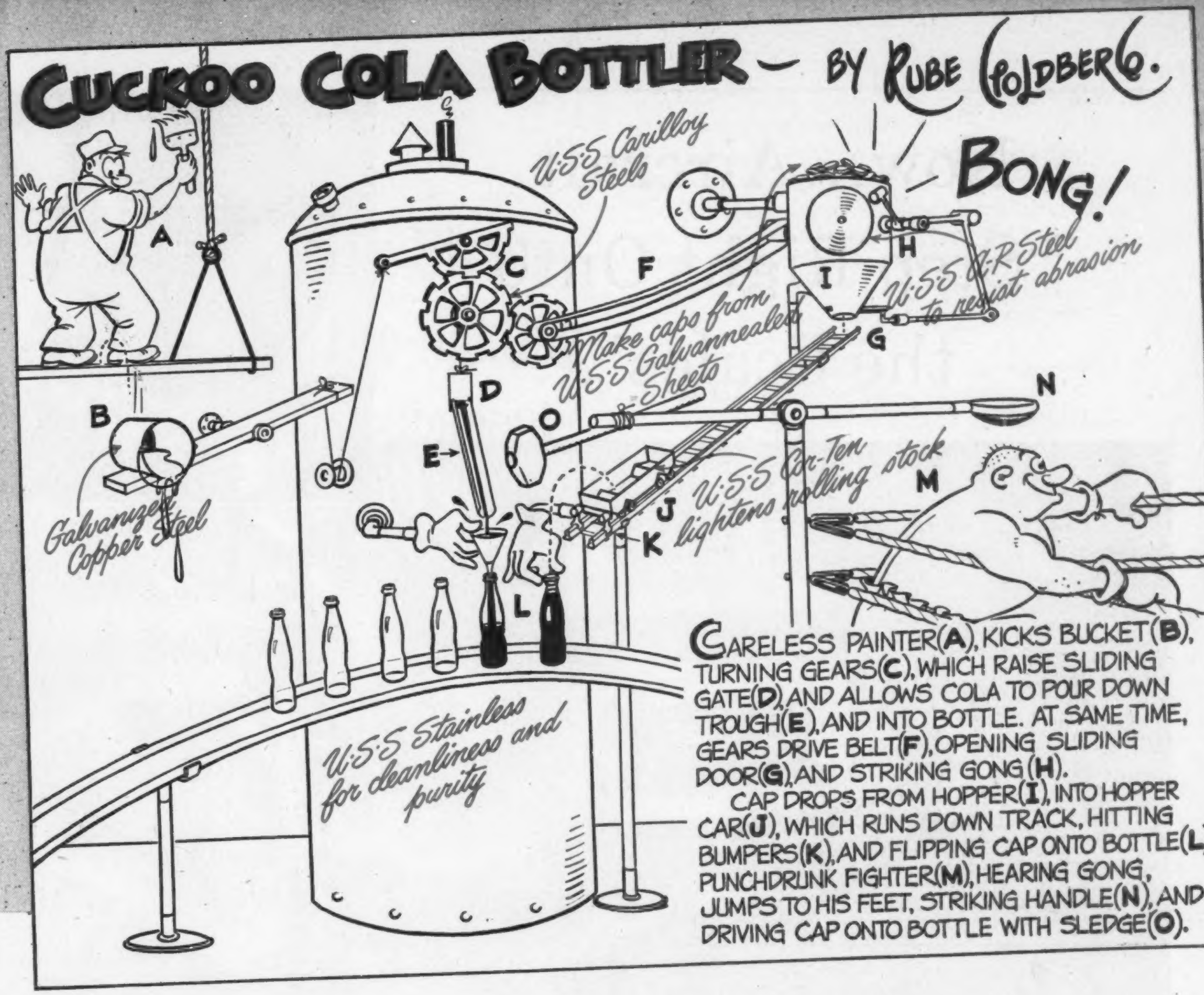
That's the question we asked manufacturers throughout the country. The answers were carefully considered and the most practical features suggested are now incorporated in the design of the new line of General Electric machine-tool transformers. They are built to handle *your* jobs, according to *your* specifications, and yet are listed as standard stock items.



Ten ratings, ranging from .075 to 3 kva, 60 cycles, 220/440 volts, will meet most of your domestic requirements. Other 25- and 50/60-cycle ratings will serve your foreign and unusual domestic applications. More on this new line in the next Designer's Digest. Meanwhile, see them in the G-E exhibit at the Machine Tool Show.

GENERAL ELECTRIC

608-50



We doubt if Mr. Goldberg's suggestion for bottling cola would prove very practical, and some of his applications may seem rather far-fetched. But there is *one* sound and proved fact brought out by the illustration . . . *only steel can do so many jobs so well.*

Where can you find a material that can equal steel's toughness for lightweight construction? What other material can withstand the severe range of temperatures . . . resist shock, corrosion, severe bending, and abrasion as well as steel?

Only steel can be produced in such an extreme variety of alloys, forms, and finishes. It can be punched, riveted, welded to perfection. It can be polished to mirror surfaces—etched, painted, or permanently coated with porcelain enamel. It can be drawn, formed, forged, machined on a mass production basis.

Our steel specialists will be glad to assist you in applying special purpose U·S·S Steels to your products to help make them more durable, more efficient, less costly to manufacture, and easier to sell.*

CARNEGIE-ILLINOIS STEEL CORPORATION
Pittsburgh and Chicago
COLUMBIA STEEL COMPANY, San Francisco, Pacific Coast Distributors
TENNESSEE COAL, IRON & RAILROAD COMPANY, Birmingham, Southern Distributors
UNITED STATES STEEL SUPPLY COMPANY, Chicago, Warehouse Distributors
UNITED STATES STEEL EXPORT COMPANY, New York
7-959

*** Have you explored the possibilities of these special purpose U·S·S Steels?**

U·S·S STAINLESS AND HEAT-RESISTING STEELS to assure high resistance to corrosion and heat, and to reduce weight.
U·S·S CARILLOY STEELS—Alloy steels for the special jobs of industry.
U·S·S HIGH STRENGTH STEELS to resist atmospheric corrosion, to increase strength without adding weight or to maintain strength with reduced weight.
U·S·S COPPER STEEL to give at least twice the atmospheric corrosion resistance of regular steel at little additional cost.
U·S·S ABRASION-RESISTING STEEL to combat wear and friction.
U·S·S HOT-ROLLED AND COLD-ROLLED STEELS to provide the basic advantages of steel, plus maximum economy in each job.
U·S·S PAINTBOND—A galvanized, Bonderized sheet that permits immediate painting and holds paint tighter.
U·S·S VITRENAMEL—Sheets designed especially for porcelain enameling.
U·S·S ELECTRICAL SHEETS for motors, generators and transformers.

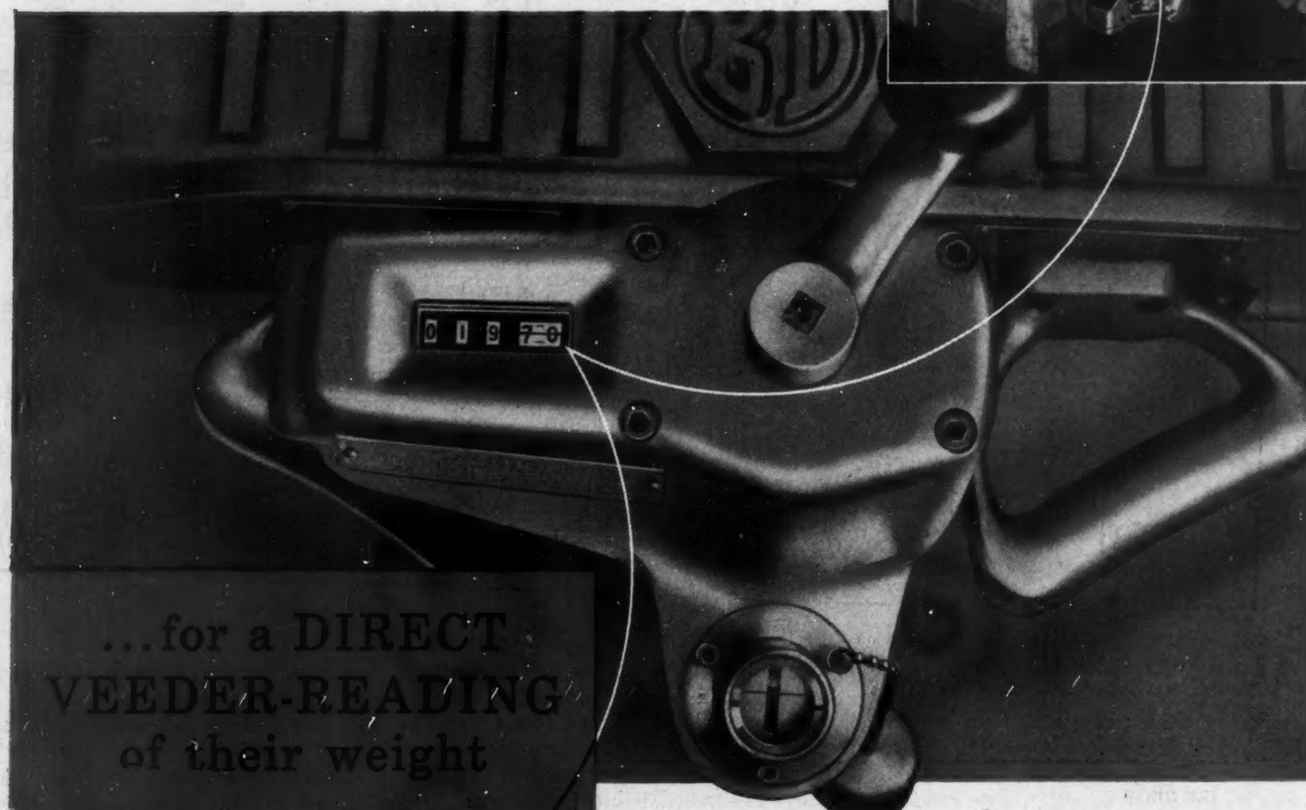
9 times out of 10 STEEL will do it better

USS STEEL UNITED STATES STEEL

IT TAKES SCRAP TO MAKE STEEL . . . PLEASE TURN YOURS IN!

UNITED STATES STEEL

Now... Aircraft "Step Right Onto the Scales"...



...for a DIRECT VEEDER-READING of their weight

VEEDER-ROOT RESET COUNTER, built into the Aircraft Loadometer made by The Black & Decker Mfg. Co., Towson, Md., approved by U. S. Bureau of Standards, Dept. of Commerce, and Civil Aeronautics Authority.

Visit Veeder-Root at the Machine Tool Show—Booth 402

To determine the weight and balance of any aircraft . . . tiny flying boat or giant transport . . . *here's all there is to do:*

Run each plane wheel up the ramp and onto the platform of the convenient portable Aircraft Loadometer. As simply as that, this accurate Black & Decker device gives an instant reading of the plane's weight.

In the Loadometer, the system of weighing levers is pivoted to a calibrated spring. This spring is extended by a micrometer screw geared to a Veeder-Root Reset Counter which gives an instant and *direct* Veeder-Reading of the plane's weight in pounds or kilograms.

In selecting a counting device for the Aircraft Loadometer, Black & Decker chose this Veeder-Root Reset Counter because it provides a *positive* reading, because the reading *remains* after the load is removed from the platform, and because the device is easily *reset* to balance at zero after each weighing. The Veeder-Root counter also provides an accurate minimum reading of five pounds and upward to the maximum capacity of 20,000 pounds.

Here again is proof that Veeder-Root not only "Counts Everything on Earth"—but also many things that fly above it. And standard or special Veeder-Root Devices, built into *your* product, can count to your advantage in more ways than you could ever figure out, alone. So talk it over with a Counting House engineer. Just write and say when you want him to call.

VEEDER-ROOT INC.

HARTFORD 2, CONN.

***In Canada:* Veeder-Root of Canada, Ltd., 955 St. James St., Montreal 3.**
***In England:* Veeder-Root Ltd., Dickinson Works, 20 Purley Way, Croydon, Surrey.**

Strange fire-fighting equipment?

No, Sir! They're "safety tools"... on *regular* duty in many hazardous operations.

What does it take to make a metal suitable for safety tools?

Many things. *First,* of course, is freedom from sparking. Other demands are... tensile strength, toughness, hardness, corrosion resistance.

And, if you want to use the tools near precision magnetic equipment, the metal also has to be non-magnetic.

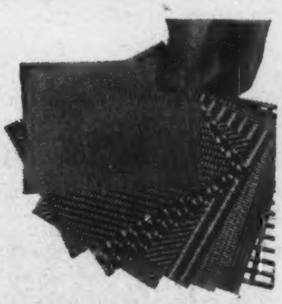
Every property you add to the list cuts down the number of metals you can possibly use.

Add: *no tendency to form dangerously unstable chemical compounds when in contact with acetylene and various explosives*... and you eliminate all but "K"* Monel and "S"* Monel.

That's why Ampco Metal, Inc., Milwaukee 4, Wisconsin, picked these two Inco Nickel Alloys for a new line of safety tools.

METAL PROBLEMS END *when you "discover" the Inco Nickel Alloys. Known as the "task metals" of industry, they'll help you fight rust, heat, corrosion, stress and wear.*
What's your problem?

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.



THESE ALSO STOP TROUBLE! *Inco Nickel Alloys are available in all forms. For example, screen cloth and filter cloth of Monel, Nickel and Inconel. Use them to replace troublesome fabric and cloth of less durable metal.*

INCO Nickel Alloys

Monel • "R"* Monel • "K"* Monel • "KR"* Monel • "S"* Monel*
Inconel • Nickel • "L"* Nickel • "Z"* Nickel* *Reg. U. S. Pat. Off.

EMBLEM OF SERVICE — INCO TRADE MARK

"Task Metals" for Industry

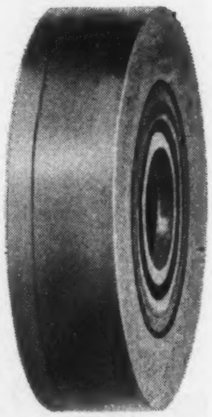
Reduce Machinery Maintenance Costs

With Parts Made of HAYNES STELLITE Alloy

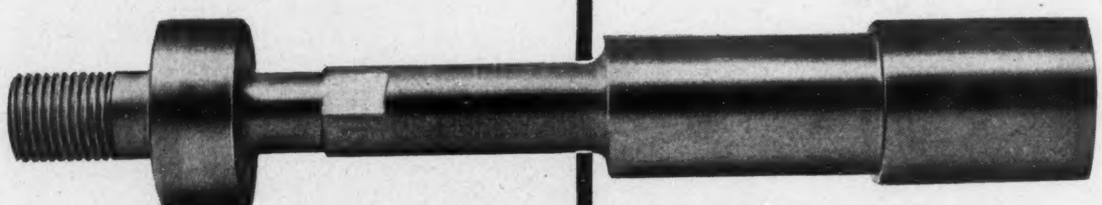
Specify castings made from HAYNES STELLITE alloy for those parts of machines and equipment that must withstand heat, wear, erosion, and corrosion. HAYNES STELLITE alloys are hard, tough, and heat resistant. They stand up under severe operating conditions . . . help keep machines in operation for longer periods of time . . . and reduce costs for repair and replacement.

HAYNES STELLITE alloy takes a high polish and has a low coefficient of friction. This means less friction and abrasive wear on moving surfaces . . . longer life for wearing parts . . . and less downtime for your machines.

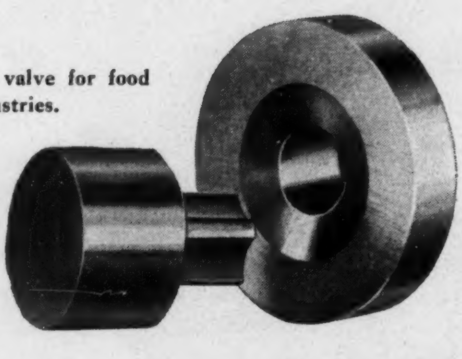
You can obtain HAYNES STELLITE machinery parts made to your specifications and ground to required tolerances.



Wire-straightening roll of HAYNES STELLITE alloy lasts 30 times longer than steel rolls.



Piston for die casting machine. This piston withstands abrasion, heat, and corrosion.



Homogenizing valve for food processing industries.

For more detailed information on how HAYNES STELLITE wearing parts can help you solve your machinery problems, write or telephone our nearest district office.

The trade-marks "Haynes" and "Haynes Stellite" distinguish products of Haynes Stellite Company.

HAYNES TRADE-MARK *Alloys*

Haynes Stellite Company

Unit of Union Carbide and Carbon Corporation

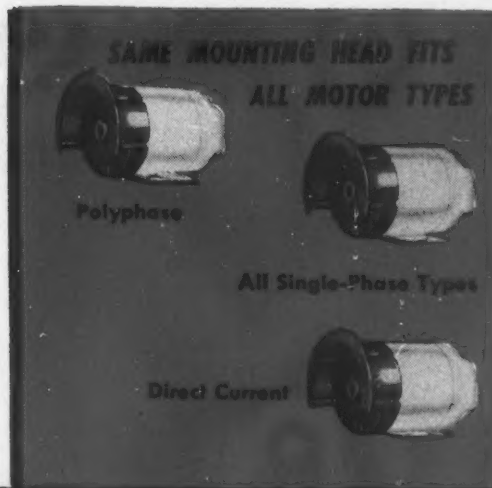
UCC

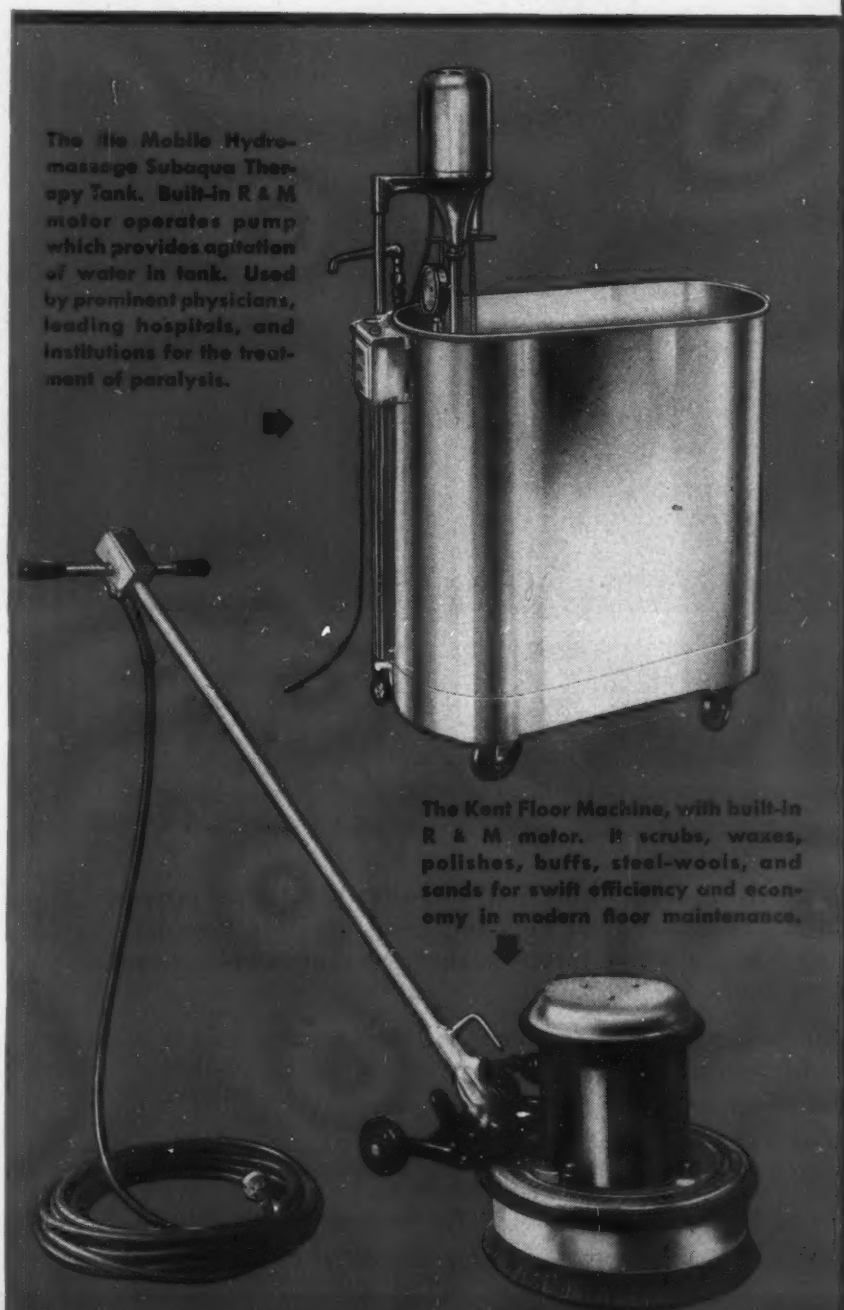
General Offices and Works, Kokomo, Indiana

Chicago—Cleveland—Detroit—Houston

Los Angeles—New York—San Francisco—Tulsa

GET BUILT-IN ADAPTABILITY WITH INTERCHANGEABLE R & M MOTORS





Simplify the application of built-in electric power to your equipment by *standardizing* on Robbins & Myers motors. Compact construction and functional mountings provide true flexibility of application. You get *full-range* interchangeability of all motor types in any one frame size. R & M's long, specialized experience can help you combine outstanding motor performance with modern, streamlined appearance.

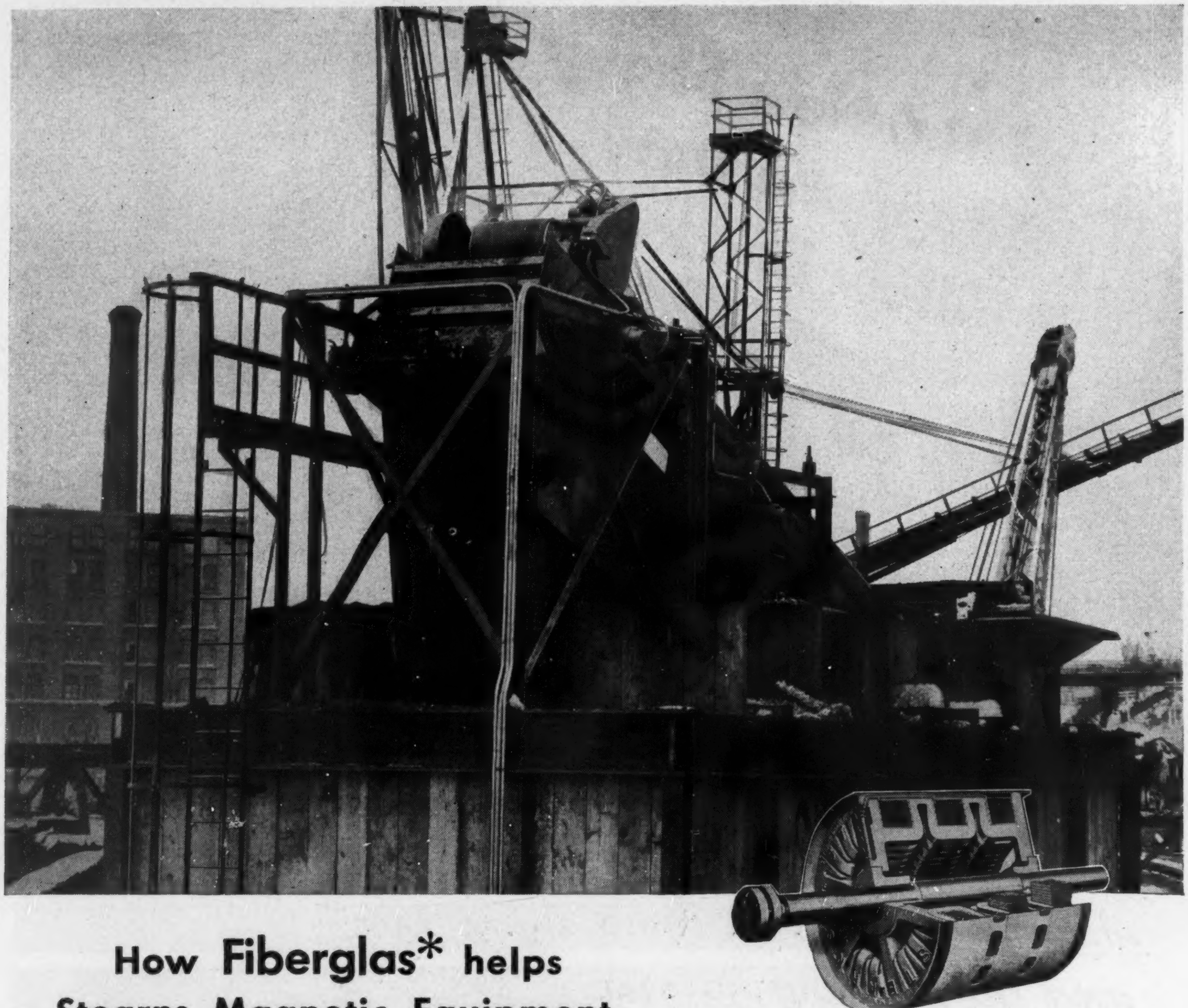
SAVES MONEY IN MANY WAYS

Engineered adaptability *lowers* costs and *simplifies* stocking, assembly, and service. Standard or special mounting heads developed for *one* type of R & M motor *fit all types* of R & M motors. Simple modifications provide open, drip-proof, weatherproof, or totally enclosed construction. In the same frame, interchangeable motor types include split-phase, polyphase, capacitator-start, direct current, capacitor, and synchronous; in various speeds, voltages, and frequencies.

WRITE FOR FURTHER DETAILS

Expert R & M engineering assistance has improved built-in motor power for many different uses. Write *today* for full information.

ROBBINS & MYERS • INC. MOTOR DIVISION · SPRINGFIELD, OHIO
In Canada: Robbins & Myers Co., of Canada, Ltd., Brantford, Ont.
MOTORS · HOISTS · CRANES · MACHINE DRIVES · FANS · MOYNO PUMPS · FOUNDED 1878



How Fiberglas* helps Stearns Magnetic Equipment "beat the weatherman"

This magnetic pulley, built by Stearns Magnetic Mfg. Company, Milwaukee, Wisc., is used to remove tramp iron from stoker coal. The use of Fiberglas Electrical Insulating Materials helps assure efficient operation under the most severe weather conditions.

Stearns' Chief Engineer Broetzmann says: "We find Fiberglas Electrical Insulation particularly effective for its moistureproof and non-hygroscopic qualities. It gives us an efficient high dielectric material and an added feature where our equipment is subject to high temperatures. Furthermore, we feel that it adds to the superiority of design and construction of Stearns Magnetic Equipment and we never stint to achieve outstanding merit in our product."

This is typical of many applications in which Fiberglas, in various forms, is being used to provide added sales value and assure more than just satisfactory performance.

Fiberglas Electrical Insulating Materials are available in forms to meet practically every insulation need. If you are concerned with the design, manufacture, use or maintenance of electrical equipment, get all of the facts. Write for Catalog EL 46-11—Owens-Corning Fiberglas Corporation, Dept. 808, Toledo 1, Ohio. Branches in principal cities.

In Canada: Fiberglas Canada Ltd., Toronto, Ontario.

***FIBERGLAS is the trade mark (Reg. U. S. Pat. Off.) of a variety of products made of or with glass fibers by Owens-Corning Fiberglas Corporation.**

OWENS-CORNING
FIBERGLAS
T.M. REG. U.S. PAT. OFF.

ELECTRICAL INSULATING MATERIALS

TAPES • CLOTHS • BRAIDED SLEEVING • VARNISHED TUBING • MAGNET WIRE • MICA COMBINATIONS • LAMINATES

It has to be A FORGING TO "*TAKE IT*" like a Forging does

Macro-etch through longitudinal cross section of Crankshaft shows fibre-like structure that is common in high quality forgings.

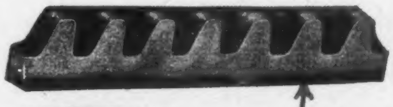
Handhole Cover Forging illustrates density of grain structure throughout this unusual shaped forging.

There is no substitute for the strength and toughness inherent in the forged fiber-like flow line structure of steel. Here is strength and toughness for unrelenting and uninterrupted performance. Here is strength and toughness for unpredictable emergencies. The forging method of fabricating parts in closed impression dies directions, controls, and concentrates the fiber-like flow line structure of metals at points of greatest shock and stress. It has to be a forging to "take it" like a forging does.

Forgings reduce parts failures and protect you and your customer from unpredictable emergencies. Forgings provide rapid assembly of complex parts by welding adaptability of widest range; forgings permit reduction of dead weight because maximum strength and toughness is obtainable in lighter sectional thicknesses. There is no substitute for the metal quality and cost reducing advantages of forgings. A recheck of every stressed part, as well as simple handles and levers, frequently reveals opportunities to improve a product, to reduce the cost of machining and finishing, to speed up assembly. Consult a forging engineer while the part is in the design stage because it is important that the design utilize fully the fibre-like flow line structure obtainable in forgings.

It has to be A FORGING TO "*TAKE IT*" like a Forging does

Note concentration of grain structure in gear tooth portions of this Cluster Gear Forging.



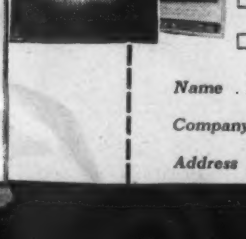
It has to be A FORGING TO "*TAKE IT*" like a Forging does

This shows result of Forging Pinion Rack in closed impression dies. Note how flow lines reinforce teeth.

It has to be A FORGING TO "*TAKE IT*" like a Forging does

Steering Lever Forging shows how forging produces density of grain structure.

It has to be A FORGING TO "*TAKE IT*" like a Forging does



DROP FORGING ASSOCIATION
605 Hanna Building • Cleveland 15, O.

☐ Booklet on "Metal Quality — Hot Working Improves Properties of Metal."
☐ "Drop Forging Topics."

Name .... *Position* ....
Company ....
Address .... *City* .... *State* ....

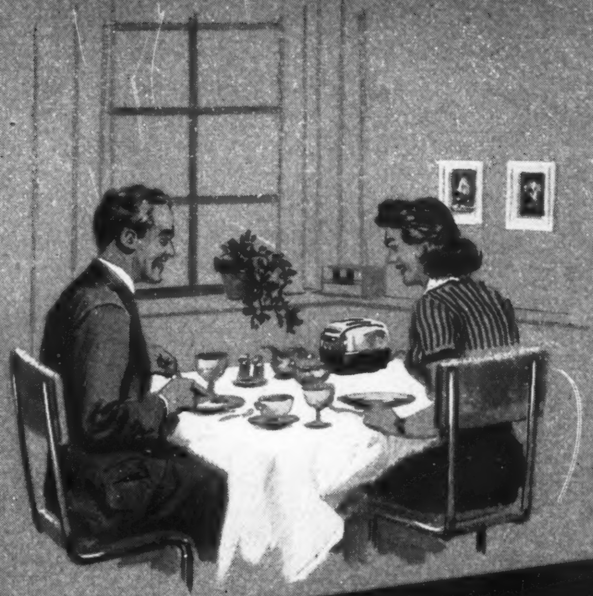
DROP FORGING ASSOCIATION

605 HANNA BUILDING • CLEVELAND 15, OHIO

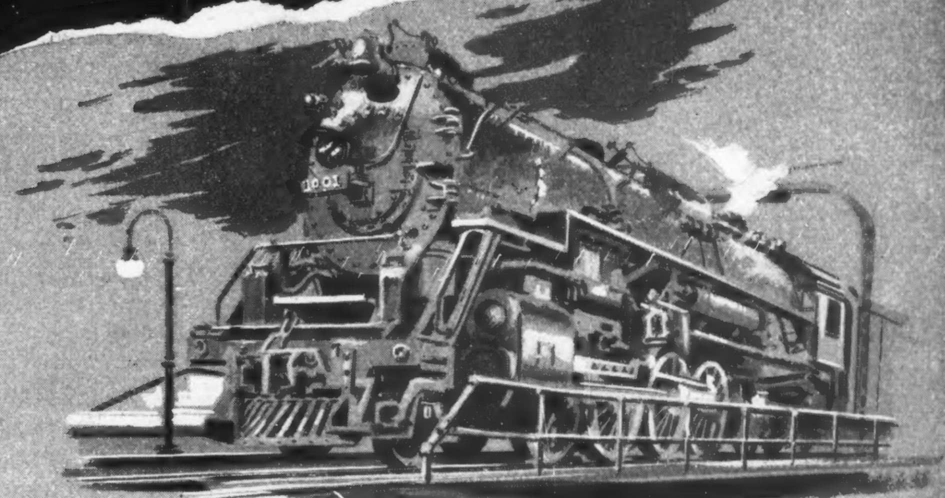
from Skyscrapers to Roller Skates...

Fastening parts together with BOLTS or RIVETS is

DEPENDABLE...SECURE...ECONOMICAL



from Toasters to Locomotives...



Regardless of excellent design, high quality and fine workmanship—if the component parts of your machines, appliances or assemblies aren't fastened together securely and dependably, the product will be a failure!

Bolts, nuts, rivets and screws are well-known and well-understood industrial fasteners. You are dealing with known physical properties when you use them. They are made from materials of recognized characteristics and strength—by familiar manufacturing processes.

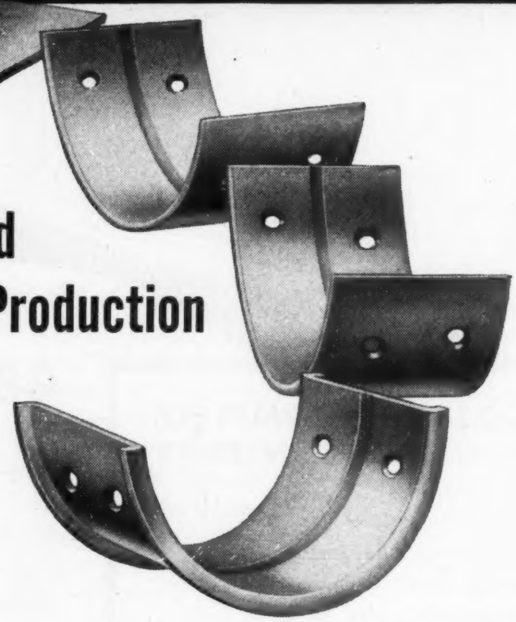
Principles of design are well-established, and checked by extensive experience. Fasteners can be obtained from any one of a number of reliable manufacturers in quantities according to your needs. Workmen are familiar with their use and no special skills are required for installation. Mass-produced fasteners are low in cost and interchangeable. ● For the success of your assemblies, use FASTENERS!

American Institute of Bolt, Nut and Rivet Manufacturers

1550 HANNA BUILDING CLEVELAND 15, OHIO

Sleeve Bearings at Low Cost!

Continuous Strip Production Method Provides Uniform Quality and Low Cost in Large Volume Production



"Thin wall" strip type, steel back, babbitt lined connecting rod and crankshaft bearings combine excellent performance characteristics with low production cost. Two of our plants specialize in the continuous strip process, producing both plain and flanged "thin wall" bearings for large-volume engine requirements.

Our complete facilities include manufacture of a wide variety of types and sizes of sleeve bearings, in large and small volume, as well as bushings, thrust washers and precision bronze parts.

Our engineering department will assist in developing bearing designs. Address:

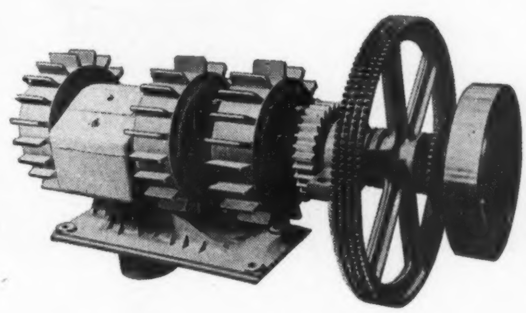
FEDERAL-MOGUL CORPORATION, 11045 Shoemaker, Detroit 13, Michigan

Power goes to work smoothly through

FEDERAL-MOGUL

Silent FEDERAL Mogul **SLEEVE BEARINGS**

FAWICK CHOSEN *for the new* MARION 33-M



New sturdiness, speed and ease of control make the new Marion 33-M an all-purpose machine in the fullest sense. Fawick equipment includes two 16E475 Fawick Swing and Propel Clutches, one 16E475 Fawick Crowd-retract Clutch, one 19E475 Fawick Boom Hoist Clutch.

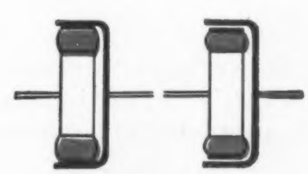
Photo at left shows 3 Fawick Air-ring Clutches on a single shaft. Air supply is obtained through use of 1 Size C Single-entry Fawick Rotorseal and 1 Size B.D Dual-entry Fawick Rotorseal, which permit independent operation of each clutch. Note Fawick high heat dissipation type clutch drums.

. . because of proven performance in the power shovel field

Fawick Clutches have amply proved themselves under the toughest field service conditions throughout the earth-moving and mining industries. That's why leading manufacturers now build Fawick into their draglines, shovels, loaders, ditchers, rollers and other materials handling equipment.

Users profit by these unique, moneysaving advantages:

- **Torque controlled, shocks absorbed by a cushion of air.**
- **No strain on any part of machine in quick starts and stops under load.**
- **No arms, levers or springs to wear or break.**
- **No adjustments to make—no lubrication required.**
- **Maintenance cost unusually low.**
- **Entire machine protected against needless loss of productive time.**



HOW IT WORKS

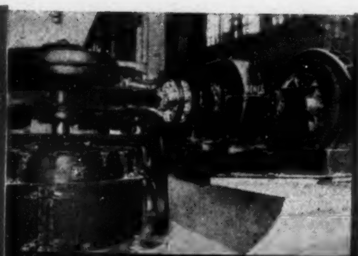
Compressed air expands the rubber-and-fabric gland to engage clutch, any degree of "grip" you need. Release the air and clutch disengages.

If clutch down time is costing you money, let our Engineering Department give you our recommendations.

FAWICK *Airflex* and **AIRING** **CLUTCH**

FAWICK AIRFLEX CO., INC. **9919 Clinton Rd., Cleveland 11, O.**

In Canada, Reneld-Coventry Ltd., Montreal, Toronto, Vancouver, Quebec • *In Britain,* Crofts Engineers, Ltd., Bradford, England



Bradley Hercules mill driven by Jones herringbone speed increaser from synchronous motor.

Oil field pumping unit using single type herringbone reducer driven by belt from gas engine.

JONES Drives that are helping to speed up production . . .

• Today every phase of production work calls for drives that will stay on the job. Jones Speed Reducers have been built for long, trouble-free service. And the records established by these speed reducers in 24 hour a day service show that they have the ruggedness and stamina for which all Jones Transmission Products are known.

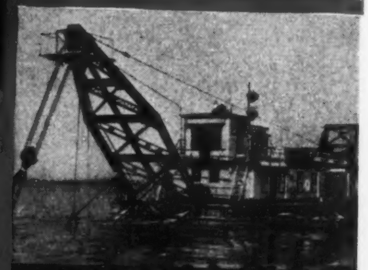
The accompanying illustrations are presented to give a general idea of the services the Jones organization is prepared to render on drive problems where speed reducers are required.

If you would like to have a condensed picture of the Jones products and engineering services, that are being widely used by industry, just ask for Bulletin No. 80, "Jones Drives for Industry".

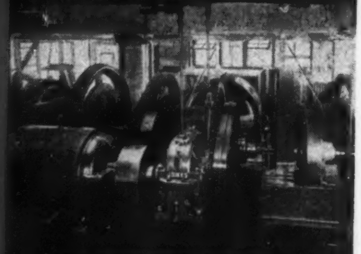
W. A. JONES FOUNDRY & MACHINE CO.
4413 Roosevelt Road, Chicago 24, Illinois

Jones

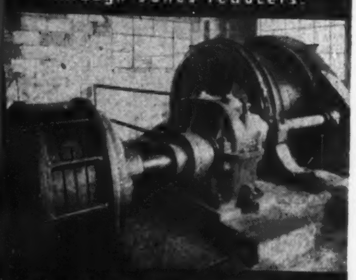
HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS • PULLEYS • GEARS • V-BELT SHEAVES • ANTI-FRICTION PILLOW BLOCKS • FRICTION CLUTCHES • FLEXIBLE COUPLINGS



Hydraulic dredge which was equipped with Jones reducers as shown in view below.



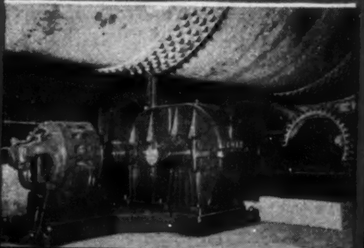
Drums and control mechanism of hydraulic dredge driven through Jones reducers.



A hoist for a coal mine driven by a Jones herringbone speed reducer.

Jones worm-helical speed reducer driving an agitator in a paper mill.

Centrifugal pump driven by a Jones speed increaser from belt drive to single cylinder gas engine.



A rotary kiln in a cement plant driven by Jones herringbone speed reducer.

Jones speed increaser driving a centrifugal pump from a Diesel engine.

One of a Kind

...or One of A THOUSAND!

EVERY TEXROPE DRIVE IS ENGINEERED FOR ITS JOB

YOU GET sound recommendations from Allis-Chalmers — recommendations backed by the greatest V-belt engineering talent and experience in the business.

Allis-Chalmers originated the Multiple V-belt drive 22 years ago. Since then, *Texrope* engineers have designed many thousands of drives, ranging from fractional horsepower units for manufacturers of small compressors, pumps or washing machines—to the largest V-belt drives ever installed. They've served: Textile, Mining, Metal working, Petroleum, Chemical . . . in fact, *every* major industry.

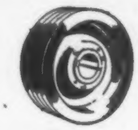
Take advantage of this vast research and experience. Bring your V-belt problems to headquarters — for the best in engineering talent — for the most complete line of V-belt equipment made.

Service is as close as your nearest Allis-Chalmers dealer or office. ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN. A 2239

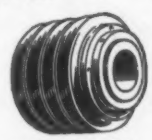
Refer to Sweet's Catalog

TEXROPE ..Greatest Name in V-Belt Drives

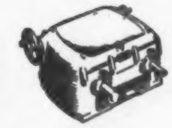
"Super 7" V-BELTS
Five Types — Sizes to suit every power transmission job.



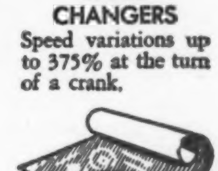
Texsteel, Texdrive, "Magic-Grip"
— sheaves in a full range of sizes, grooves.



"Vari-Pitch" SHEAVES
Exact variations in speed, stationary or motion control.



SPEED CHANGERS
Speed variations up to 375% at the turn of a crank.



ENGINEERING
Finest V-Belt engineering talent in the world—at your call.

TEXROPE "Super 7" V-Belts result from the cooperative research of two great companies — Allis-Chalmers and B. F. Goodrich. They are sold only by A-C.

ALLIS-CHALMERS

One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products

1847 1947 A CENTURY OF SERVICE to Industry THAT MADE America Great

"I think many designers will save time in the long run if they will decide, at the start of a job, to use standard motors." Thus speaks D. R. Percival, Electrical Engineer, Machine Division, Norton Company. "We'll eliminate the exhaustive engineering tests we used to make on fractionals. With horsepower, service factor, breakdown torque, and starting current all rated on a clear-cut, uniform basis we'll know *in advance* whether the motor will handle the job."

"The big thing about the new small-power motor standardization plan, to me, is the promise it holds of increasing the *availability* of all makes of motors," says Ben B. Breslow, President, Utility Appliance Corp. "We'll stand a better chance of getting 'off-the-shelf' delivery of motors if they are a big-production item, instead of a special. We cut a few production corners, too, by using standards. We eliminate special jigs and fixtures, and the need for making universal mounting bases and adapter plates. We can 'standardize' more of our own assembly methods."

More for your money with

STANDARD *fractional-horsepower* MOTORS

FOR EXAMPLE, the General Electric machine tool motor gives you a fractional engineered specifically for rough and tumble industrial service. Totally enclosed, these motors have a rigid base and ball bearings which make them suitable for jobs where thrust is encountered. Firmly anchored windings stand up under frequent start-stop service, plugging, and momentary overloads. Descriptive bulletins on this and the 10 other main groups of standard G-E motors shown below may be obtained by writing to your nearest G-E office or *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

THE NEW MOTOR INDUSTRY STANDARDS for defining motor rating and performance and the new dimension standards for small-power general-purpose and definite-purpose* motors were not set for the convenience of General Electric—or any other electrical manufacturer. They were arrived at after careful study of thousands of motor orders and months of co-operative work by industry associations and the National Electrical Manufacturers' Association. They represent the best possible co-ordination of motor design with the current needs of small-power motor users. And—these standards will be modified as design trends change, to *keep* in step with user needs. Standardization is not static!

GENERAL ELECTRIC offers you three definite advantages as a source of fractional-hp motors. First we give you the widest variety of standard general-purpose and definite-purpose motors to choose from—some 1600 in all. Second, General Electric motor-exchange and repair-service plans have been developed on a country-wide scale to give prompt, low cost motor repair or replacement service to your customers. Finally, in all G-E motors you get the quality extras which standards can't cover. You get the benefit of the newest developments in bearing design, insulation, and winding techniques. You get the best possible protection against electrical breakdown and mechanical wear and tear.

**Definite-purpose motors are standard motors specifically designed for jobs where general purpose motors (built for broad application) are not ideally suited*

GENERAL ELECTRIC

706-82


Here's How The Magnetic Plug Prevents Wear!
Pulls Iron and Steel Particles Out of Oil
A powerful, permanent magnet in the Lisle Magnetic Plug pulls abrasive metal particles out of a lubricant. The illustration below shows how Lisle Plugs are used in place of ordinary plugs in any housing where gears, bearings or other moving parts operate in a bath of oil. Low cost Magnetic Plugs will add to the value and life of your product. Send for free sample plugs for testing.
Lisle Magnetic PLUGS
Manufactured by LISLE CORPORATION
Box 1003 Clarinda, Iowa

To Men Who Know Motors

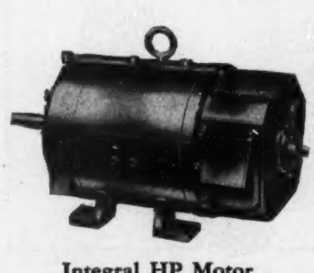
... we could end our message here!

To men who know motors, a picture like this is worth the proverbial ten thousand words. It speaks with convincing eloquence of craftsmanship to which any motor builder could point with pride.

If you visit Star's modern plant, you'll see scores of examples of the same painstaking craftsmanship that pays off in outstanding performance for Star customers.

Star not only builds motors well, but also takes leadership in design. Star led in welded steel construction ... pioneered ball bearing motors ... developed the famed Star Built-in Magnetic Disc Brake for motors ... pioneered in the field of gear-motors.

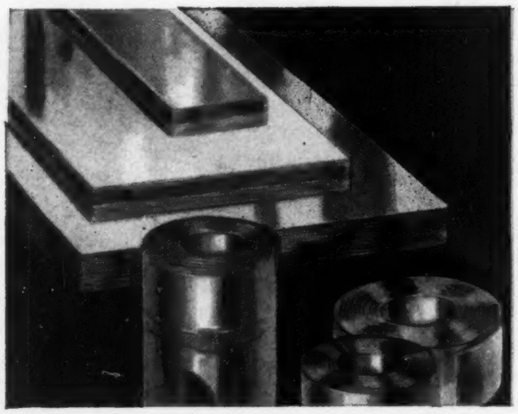
Whether you need special or standard motors, ½ to 200 H.P., it will pay to learn why so many critical buyers specify "Star". Star Electric Motor Co., 200 Bloomfield Avenue, Bloomfield, N. J.

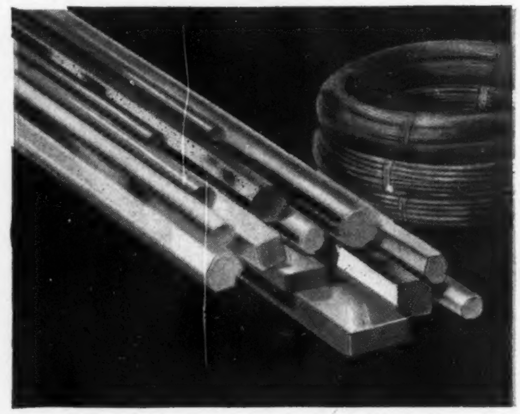


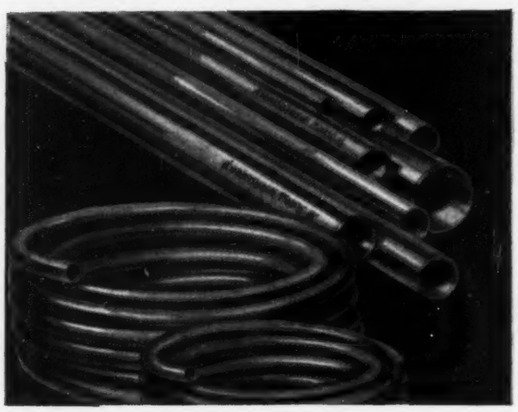
Integral HP Motor for Direct Current

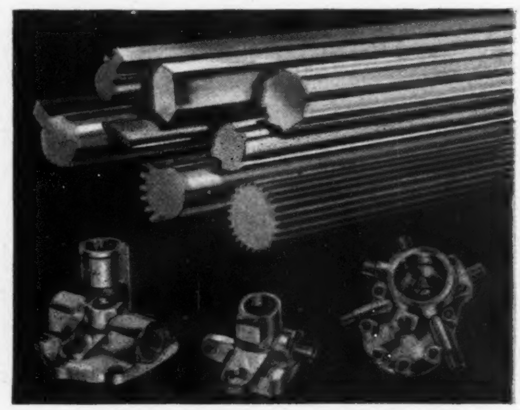
STAR MOTORS

POWER PACKAGED AS YOU NEED IT









MOST VERSATILE
OF ALL COMMERCIAL METALS

And today, through modern metallurgy, that age-old versatility of copper alloys is enhanced in several ways... by combining a number of desirable properties in a single alloy... by widening the choice of materials for ordinary and specialized uses... by assuring products that give unexcelled performance under a wide variety of service.

The American Brass Company produces Anaconda Copper and Copper Alloys in practically all commercial forms; also in special shapes and die pressed forgings. Whether your requirements are large or small, the personnel of Company Warehouses, District Offices and Anaconda Distributors will be glad to serve you. 47115

THE AMERICAN BRASS COMPANY

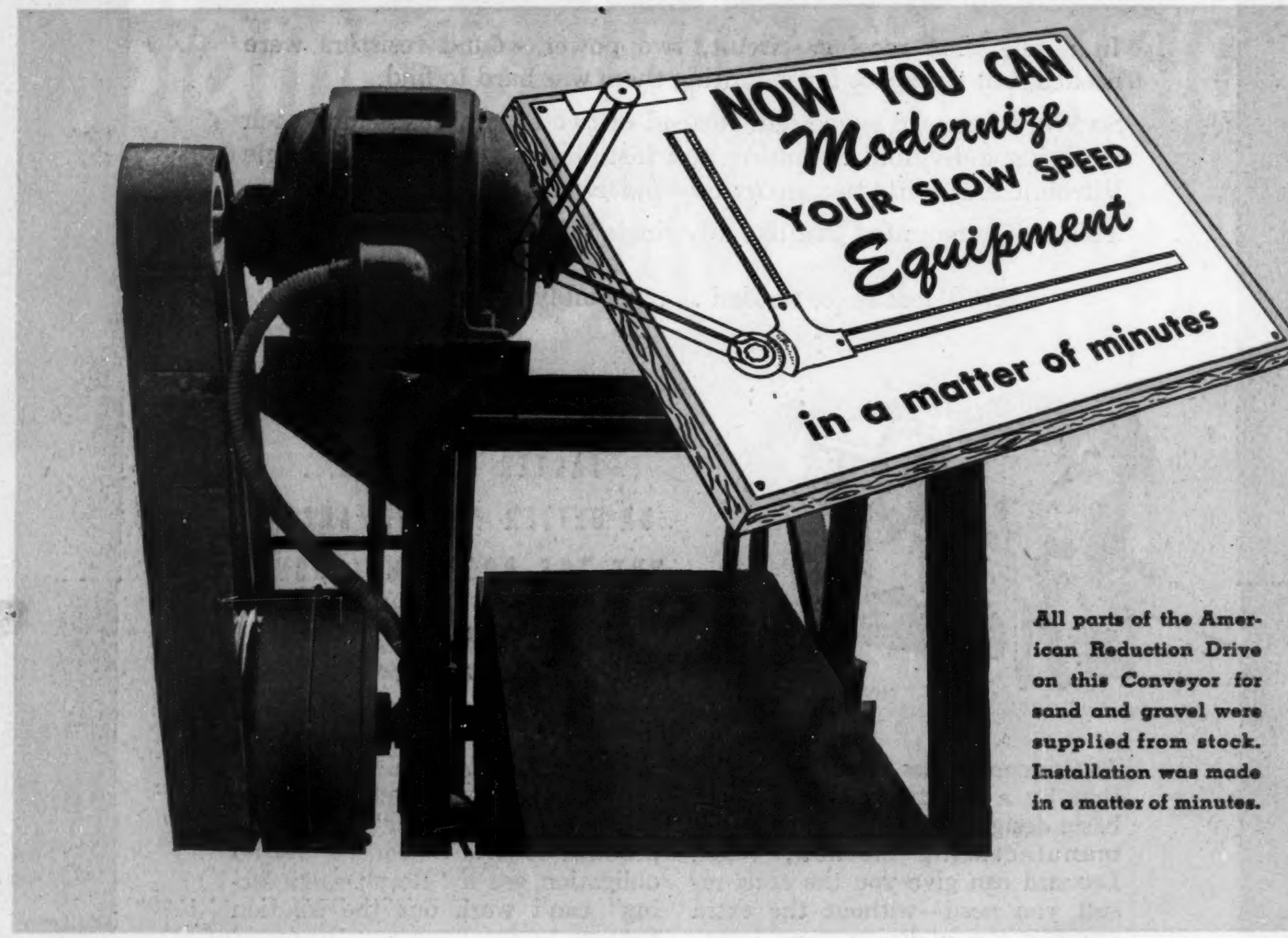
General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA

***Anaconda* COPPER and BRASS**



All parts of the American Reduction Drive on this Conveyor for sand and gravel were supplied from stock. Installation was made in a matter of minutes.

Right now you can *quickly* give your slow-speed equipment the modern advantages of economical speed reduction! Just one, easy step—and you add greater flexibility, efficiency, and space saving design to that slow-speed machine on your drawing board. All you need do is specify American Reduction Drives—including the Speed Reduction Unit with a standard speed ratio of 13 to 1, and a primary belt drive of the required ratio—right from dimensions shown in the Catalog. You can be sure the parts you specify will be immediately available because they are standard, stock items. Any driven speed between 11 rpm. and 154 rpm. is obtainable just by changing the ratio of the primary belt drive.

What's more, no special foundations or supports are needed—the Speed Reduction Unit mounts right on the shaft of the driven machine.

Users of your machinery equipped with American Reduction Drives benefit, too! Strains on motors and gears are eased because the primary belt drive cushions the impact of starting and shock loads. And the proper speed plus less maintenance down time pays off in increased production. Find out now how easy it is to give your slow-speed equipment the modern advantages of economical speed-reduction. Send for your copy of the American Reduction Drives Handbook, today.

MAIL THIS NOW!

THE AMERICAN PULLEY COMPANY
4238 Wissahickon Ave., Philadelphia 29, Pa.

I'd like the complete engineering data and drive selection tables contained in the American Reduction Drives Handbook. Please send my free copy to:

NAME ______ TITLE ______

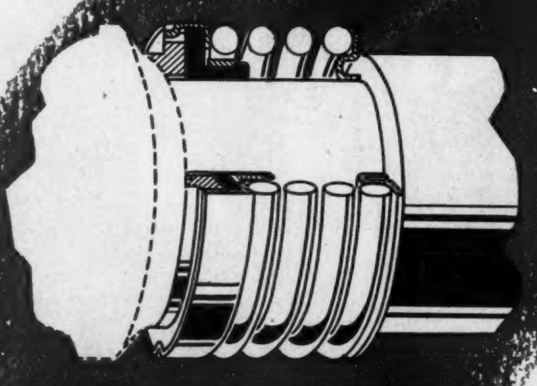
COMPANY ______

ADDRESS ______

CITY ______ ZONE ______ STATE ______

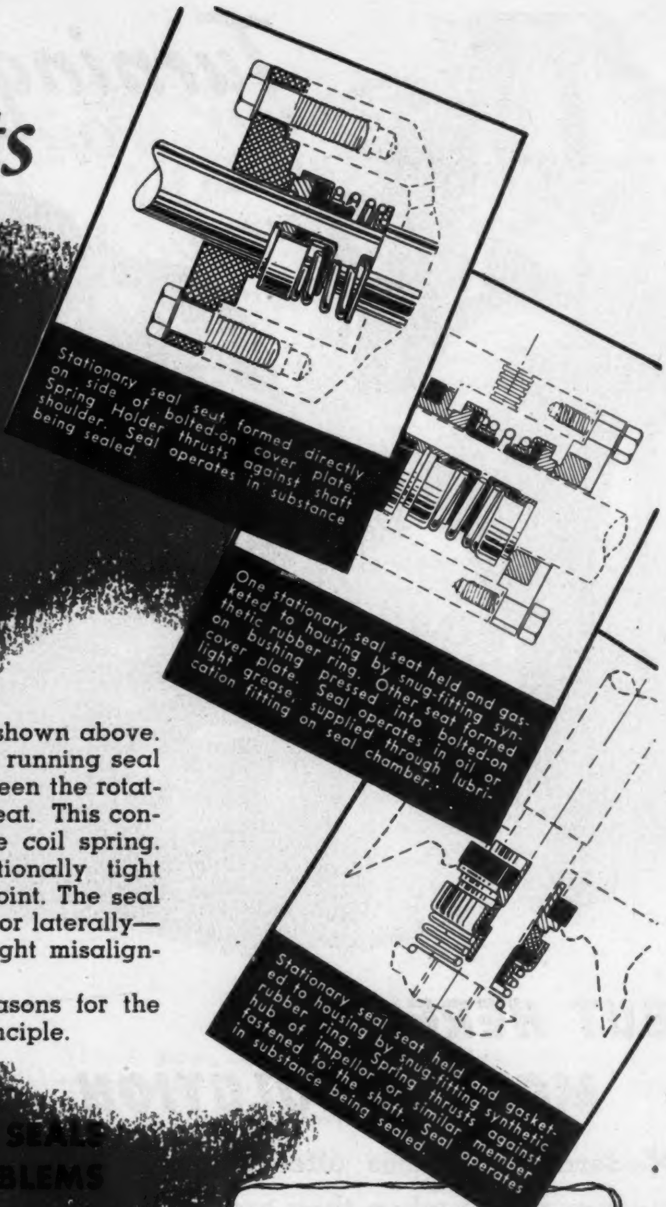
The American Pulley Company
4238 WISSAHICKON AVE., PHILADELPHIA 29, PA.

SEAL
Rotating Shafts
WITH CERTAINTY



Simplest adaptation of the Rotary Seal principle is shown above. The entire Seal Assembly rotates with the shaft. A running seal joint is formed by continuous, intimate contact between the rotating seal face and the mating fixed stationary seal seat. This contact is maintained by the pressure exerted by the coil spring. The flexible, elastic driving member, fitting frictionally tight around the shaft, acts to prevent leakage at that point. The seal face can adjust its running plane—either angularly or laterally—to compensate for shaft vibration, deflection or slight misalignment.

Simplicity in design and function are basic reasons for the efficiency and practicability of the Rotary Seal principle.



CUSTOM-ENGINEERED ROTARY SEALS SOLVE TOUGHEST SEALING PROBLEMS

Since 1931 the Rotary Seal Company has specialized in adapting the sound principle covered by its basic patents to the creation of effective, practical solutions of the many difficult problems in sealing rotating shafts.

Analyses of individual case results throughout the years have enabled Rotary Seal engineers to design continually improved seals for a wide variety of application.

Today, leading industrial companies throughout the country depend on Rotary Seal for fool-proof, efficient performance. They know they can "seal with certainty" with a Rotary end-type seal designed expressly for the particular application.

If you have a sealing problem, no matter how difficult it may appear, let Rotary Seal submit a recommendation. You will assume no obligation. Just send complete drawings of shaft assembly and full information on operating and service conditions.

Is Your Sealing Satisfactory?

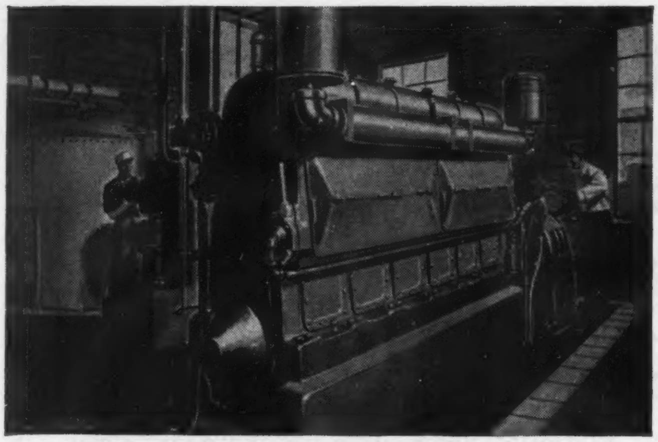
Possibly, you feel that you haven't a sealing problem, or that your present sealing method is "getting by." But, do you get maximum efficiency, performance and lowest ultimate cost?

No matter what method of shaft sealing you are now using you may be surprised at the advantages Rotary Seals can give your product . . . in protection of product quality . . . in fewer maintenance and service calls . . . in assurance of greater product efficiency and long life.

Send for Booklet "Sealing with Certainty on Rotating Shafts" completely describing and illustrating Rotary Seals.

THE ROTARY SEAL COMPANY mechanical seals for rotating shafts

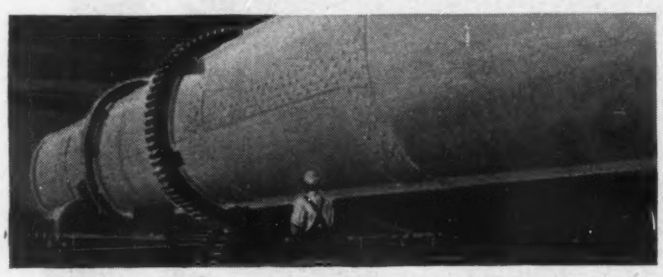
ROTARY SEAL COMPANY, 2022 N. Larrabee Street, Chicago 14, Ill.



INDUSTRIAL GEARS. *High quality spur, helical, worm and bevel gears to meet practically any requirement.*

ACTUATORS AND POWER UNITS *assure control from a remote point. Used on many of the most modern airplanes they may aid in solving your control problems.*

A-Q (Aircraft Quality) GEARS
are used on Pratt & Whitney Wasp Major engines, jet propulsion engines and for many other applications.



GIANT GEARS. *Complete facilities to produce gears up to 20 feet in diameter for sugar mills, cement kilns and other uses.*

SPEED REDUCERS. *A wide variety of sizes and ratios in helical and worm gear reducers to meet every industrial need.*

if you transmit power call on

FOOTE BROS.

Regardless of the problem you face in production or transmission of power, Foote Bros. engineers can help you find a solution.

It may be gears—spur, worm, helical or bevel—for machine tools, road building machinery, tractor transmissions, diesel engines, or practically any application. *Foote Bros. produces high quality gears in any quantity to meet any need.*

It may be "A-Q" (aircraft quality) gears for use in applications where the characteristics of high speed, greater compactness, light weight, high efficiency, and low noise level are important. *Foote Bros. A-Q gears closely approach theoretical perfection.*

It may be accessory drives on jet propulsion engines, actuators to provide exact control of linear or rotary motion from a remote point. *Foote Bros. actuators and power units are serving on many of the nation's revolutionary aircraft engines and airplanes.*

It may be speed reducers for a paper mill, a steel plant, a chemical plant or any other industrial application. *Foote Bros. makes reducers in a wide range of sizes and ratios to meet your requirements.*

To manufacturers, Foote Bros. offers two completely equipped plants—nearly a century of manufacturing experience—a thoroughly staffed engineering department to assist in the design and application of equipment to meet any power transmission problem.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. O 4545 S. Western Boulevard • Chicago 9, Illinois
Three bulletins on Foote Bros. products are available. Check the coupon for the ones you are interested in.

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☐ BULLETIN "AIRCRAFT QUALITY GEARS"
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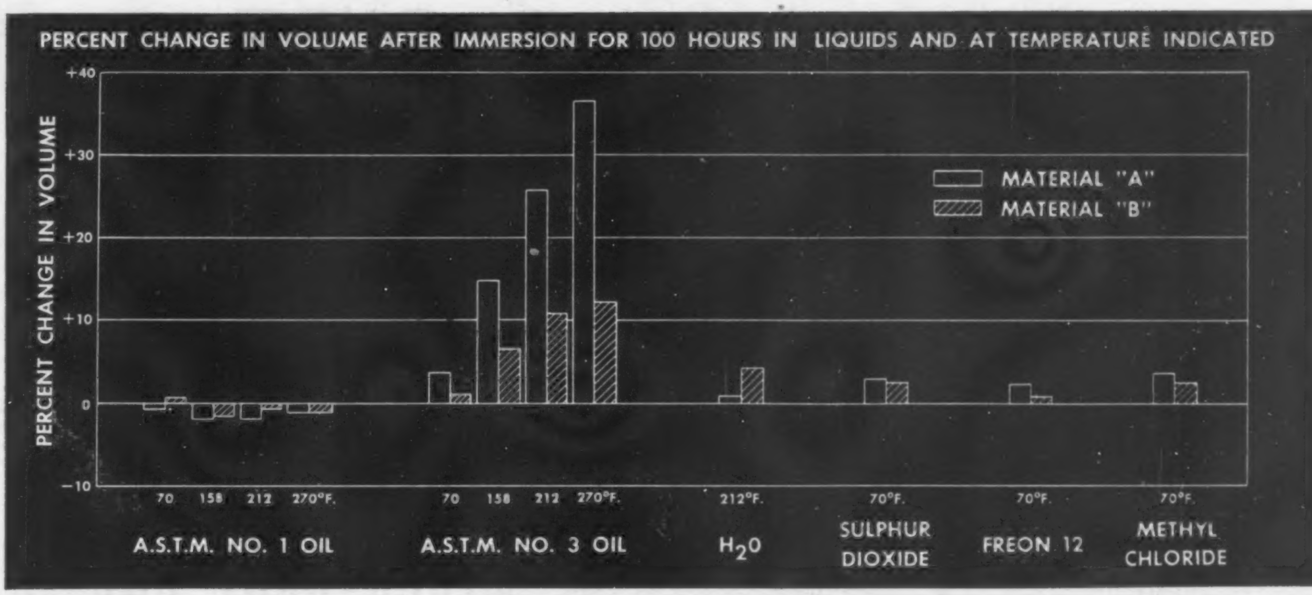


CHOOSING GASKETS FOR WIDE-RANGE USES

Careful balance of required properties needed for best performance

When a unit is designed to operate with one type of fluid at low pressure and at average room temperatures, gasket or seal specification is easy. But when the unit is to be used with several fluids at varying temperatures and pressures, the gasket chosen must offer the optimum balance of all needed properties.

The most obvious effect a fluid may have upon a gasket material is dimensional change. A fluid will shrink a gasket if it can dissolve part of the gasket's ingredients. The same fluid may swell another compound if that material tends to absorb part of the fluid. And certain combinations of materials and fluids can cause both phenomena to occur simultaneously. In the latter case, the gasket may remain stable in volume though it is changed chemically.

Fluids may also affect the durometer hardness and frictional properties of a seal. If the gasket is improperly selected, plastic flow, stickiness, or loss of tensile strenght may result. These effects can be aggravated by heat. Especially severe are conditions under which a gasket is alternately wet and dry. This may destroy the efficiency of the gasket by making it either porous or hard, depending on the particular fluids and materials involved.

Furthermore, if part of the gasket's ingredients are dissolved by the fluid, those ingredients may contaminate the fluid to such an extent as to make it unusable. Some fluids, when in contact with various compounds, also set up chemical reactions that tend to corrode certain metals.

Skillful compounding often can produce a material that performs well despite divergent operating conditions. For example, a manufacturer had been specifying a certain material for a shaft seal (Compound A, charted above). Though this material was considered satisfactory in view of the varied conditions under which it operated, Armstrong was assigned the task of finding something better. The Armstrong Research Laboratories then developed Compound B. As shown in the chart above, this new material offered greater over-all resistance to the fluids encountered. Consequently, it provided a higher safety factor and more satisfactory performance.

When selecting a gasket material for wide-range fluid resistance, we suggest you discuss your particular application with an Armstrong Representative. He will be glad to analyze the conditions it imposes and supply you with samples of the Armstrong materials proved to be most suitable.

If you prefer, send drawings and details to us. You will find our recommendations keyed to good current gasketing practice.

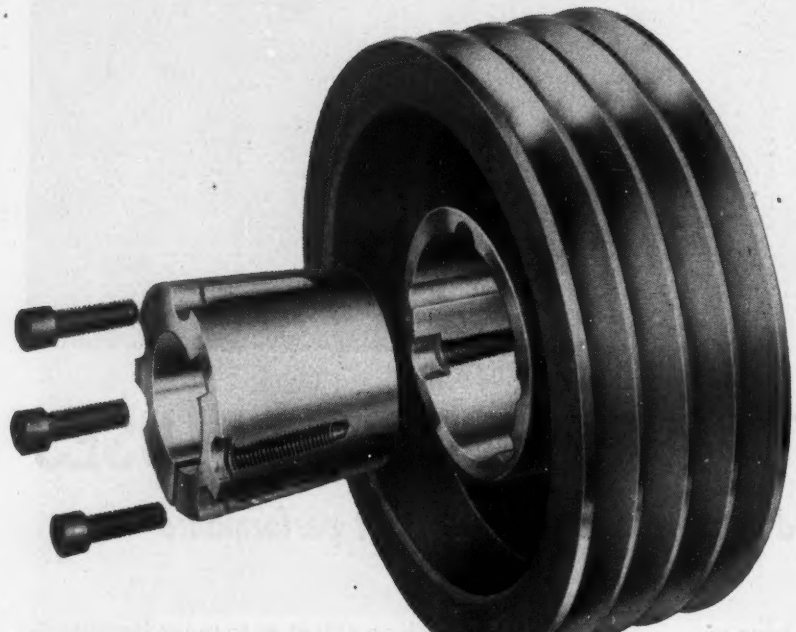
SEND FOR FREE BOOKLET

Write for the new, 20-page 1947 edition of "Armstrong's Gasket and Sealing Materials." It includes specification data on more than 40 of Armstrong's resilient sealing materials and also helpful hints on their proper application. Write today to Armstrong Cork Company, Gaskets and Packings Department, 5109 Arch Street, Lancaster, Pa.

ARMSTRONG'S
GASKETS · SEALS · PACKINGS

Cork Compositions • Cork-and-Synthetic-Rubber Compositions
Synthetic Rubber Compounds • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork

TAPER-LOCK BRAND



THE NEW TIME-SAVING TAPER BORE SHEAVE

TAPER-LOCK has the simplest, surest mechanism ever devised for holding wheels to shafts...TAPER-LOCK saves time. You slip it on the shaft, line it up and tighten while sighting...TAPER-LOCK runs true. It holds with a firmness equivalent to a shrunk-on fit, yet it disengages with less effort than any other sheave.

TAPER-LOCK sheaves are available in all the most wanted sizes. Thus Dodge has not only created a great new product in the power transmission field, but has made this product adaptable to needs throughout industry.

TAPER-LOCK is a striking example of the new Dodge products which help you put more power on the job — cut costs and increase production. The savings which Dodge equipment make possible will be important to you in the competitive days ahead. Get the full story — now.

DODGE MANUFACTURING CORPORATION
MISHAWAKA • INDIANA

IN ALL THESE STOCK SIZES:

CLASS SHEAVE	PITCH DIAMETER	NUMBER GROOVES	TOTAL SIZES
DUAL DUTY "A"	3.0 to 18.0	1 to 6	150
DUAL DUTY "B"	4.6 to 18.4	1 to 6	114
B	5.4 to 38.0 20.0 to 38.0	7 to 10 2 to 10	76 36
C	9.0 to 44.0	3 to 10	128
D	13.0 to 33.0	4 to 10	77

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER

He's a factory-trained specialist qualified to analyze your mechanical power transmission needs and recommend correct equipment. Consult him without obligation. Look for his name under "Power Transmission Equipment" in your classified telephone directory.

NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS

10,000-cycle 15 K.W. motor-generator TOCCO machine annealing brass tubes.

THE TURNER BRASS WORKS, Sycamore, Illinois, reports these benefits from the annealing of brass tubes for plumbing fixtures with TOCCO Induction Heating:

233% FASTER. Heating ½″ on end of 1½″ diam. sink tail pieces to 1100° F. for annealing prior to flanging and bending. TOCCO heating with motorized work feed produces 233% more output than former method. Cost cut from \$0.005 to \$0.0015 per anneal.

On trap bend tubes, TOCCO cut cost from \$0.0073 to \$0.0027 per anneal. Here, TOCCO makes three anneals simultaneously in ten seconds.

IMPROVES QUALITY. TOCCO's accurate temperature control produces finer grain structure and less scale, prolonging life of tools and reducing cost of subsequent buffing operations.

TOCCO Engineers will help you make similar cost-cutting improvements in *your* operations.

THE OHIO CRANKSHAFT COMPANY

FREE BULLETIN

Mail Coupon Today

THE OHIO CRANKSHAFT CO.
Dept. B-4, Cleveland 1, Ohio

Send free copy of booklet, "INDUCTION HEATING."

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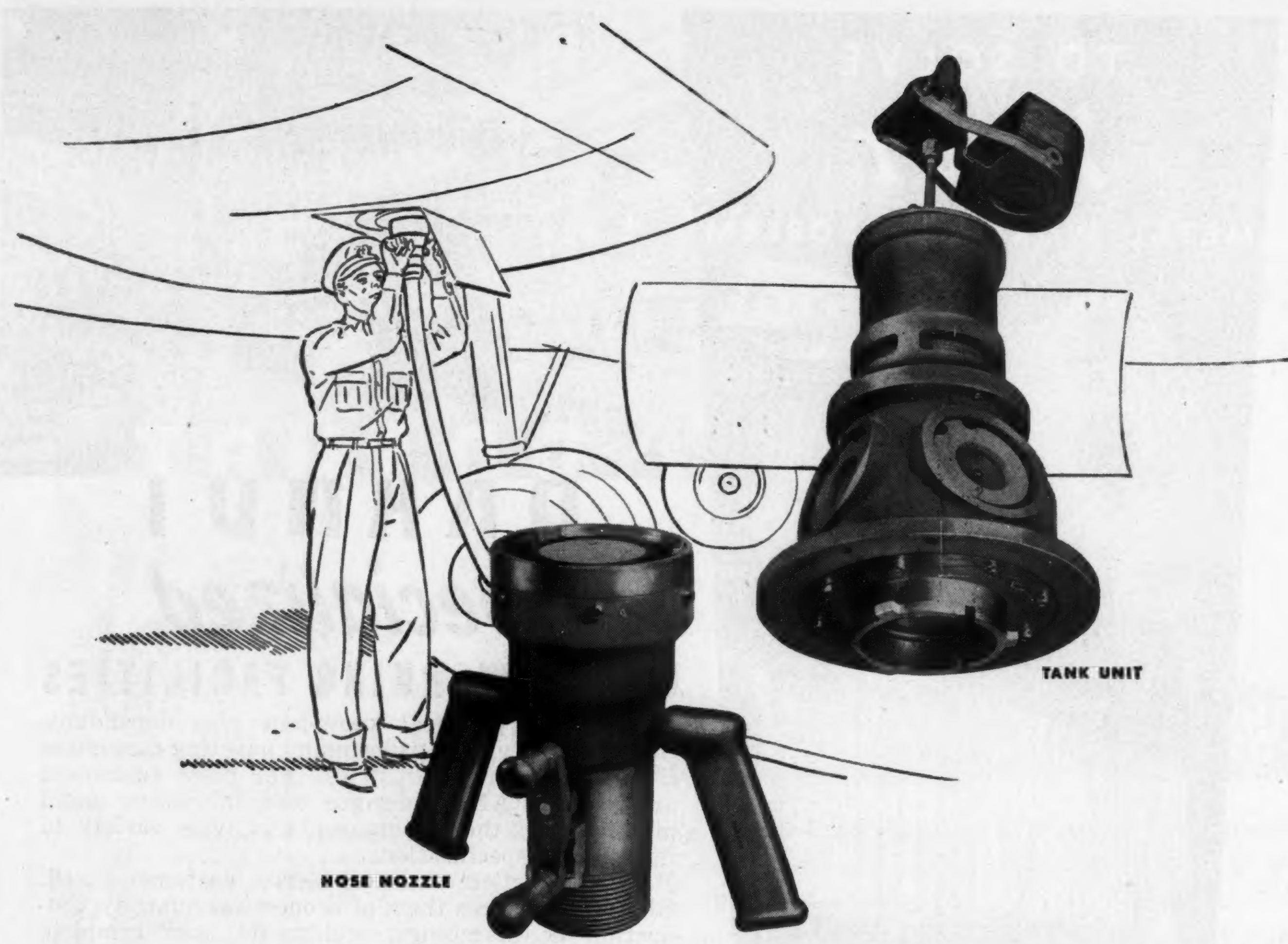


To Turn Ground Time into Flight Time

THE NEW PARKER UNDERWING FUELING EQUIPMENT

If you fly at a cruising speed of, say 275 mph, you're losing 23 revenue miles every five minutes you're on the ground. You can save those miles—with the new PARKER underwing fueling tank valve and mating hose nozzle.

For example, in actual operation, standard commercial transport planes have been gassed up—1,000 gallons—in 8 minutes! Using ordinary methods, it would take at least 50 minutes—more than six times as long!

But time is not all you'll save. Underwing fueling is *safer*—no climbing on icy wings, no open fire hazard. It's *cleaner*—no dirt can blow into the tank, and there's no overflow to spill on the runway. It's *easier on maintenance*—no scraping over de-icer boots and wing surfaces.

PARKER Underwing Fueling Equipment (to specifications approved by the Air Transport Association) is designed to handle up to 200 gallons per minute. Can you save on-the-ground time at that rate? Let us furnish complete details. Ask for Bulletin 520.

OTHER PARKER AIRCRAFT PRODUCTS

- **Tube Fittings—AN standard and flareless types.**
- **Fuel Valves—shut-off, selector, including motor-driven.**
- **Hydraulic Valves—check, relief, restrictor, shuttle, etc.**
- **Air and Vacuum Valves, Swing Check Valves.**
- **Engine Primers, Strainers, Drain Cocks.**

Write for Bulletin A41, reviewing PARKER Aircraft Products.

THE PARKER APPLIANCE COMPANY
17325 Euclid Avenue • Cleveland 12, Ohio
Plants: Cleveland and Los Angeles
Offices: New York, Cleveland, Chicago, Los Angeles, Dallas, Atlanta
Distributors in Principal Cities

Parker
TUBE FITTINGS • VALVES

IF YOUR PRESENT product development plans require the accurate control of temperatures or pressures, the regulation of valves, the movement of switches or shutters . . . you're invited to bring your problems to Fulton Sylphon's bellows engineers.

Here, we specialize in creating and producing bellows and bellows assemblies of just the right metals, and in just the right sizes and styles to meet the specific requirements of customers throughout industry.

Backed by over 40 years' experience in this field, our engineering staff and extensive production facilities are at your disposal . . . for the development of an idea or the manufacture of large volume orders.

Catalog RK-1300 gives complete information. Write for your copy today.

FS
FIRST WITH BELLOWS

THE FULTON SYLPHON CO. KNOXVILLE 4, TENN.

FULTON SYLPHON

Temperature Controls • Bellows Devices • Bellows Assemblies

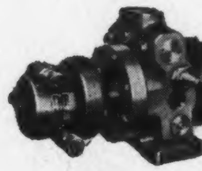
Canadian Representatives, Darling Brothers, Montreal

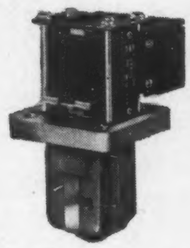

CARMET Carbide
Drawing Die Insert
for Stainless Steel
50% More Production, Perfect Parts
with CARMET Draw Dies
This was a *real* "problem" job, but the Carmet-insert draw die above solved it. It not only turned out 50% more stainless steel parts per day, all perfect compared with considerable spoilage before . . . it also produced 50,000 parts, *with no re-working*, compared to less than 1000 parts for the total life of the die it replaced. Remarkable, yes—but you can always expect unusual results from Carmet-edged tools on drawing, blanking or cutting operations, or from Carmet machine parts where great wear-resistance is required. ● Just remember, in addition to the regular line of Carmet cutting tools, we specialize in preforming sintered carbides to practically any specification—supplying them either "as formed," or finish-ground ready for use. *Let us work with you.*
AL
Steel Corporation
DIVISION, Ferndale (Detroit) Michigan

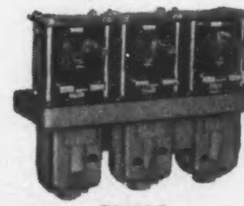
● IN PROPER COMBINATION...

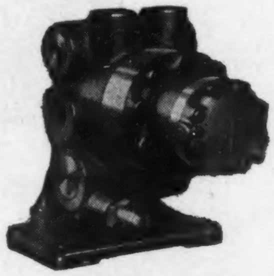
These Standard SUNDSTRAND Hydraulic Elements

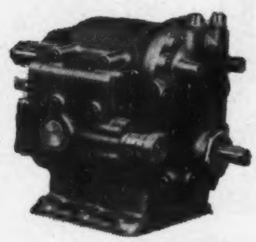

FLUID MOTORS


PUMPS

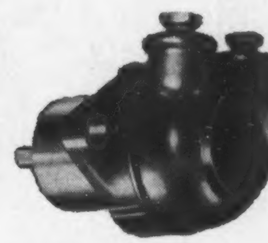

SINGLE SOLENOID VALVES


TRIPLE SOLENOID VALVES


CLAMPING PUMPS


TRANSMISSIONS


FOUR-WAY VALVES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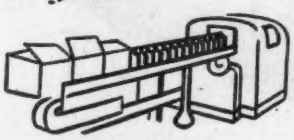

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MACHINE TOOLS

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If you're designing new equipment or re-designing present models, a Sundstrand hydraulic application engineer will be glad to assist with the circuit design. Many designers have found better solutions to requirements similar to those listed at the left . . . better circuits with less equipment, through the use of these time-tested standard elements and Sundstrand's engineering service.

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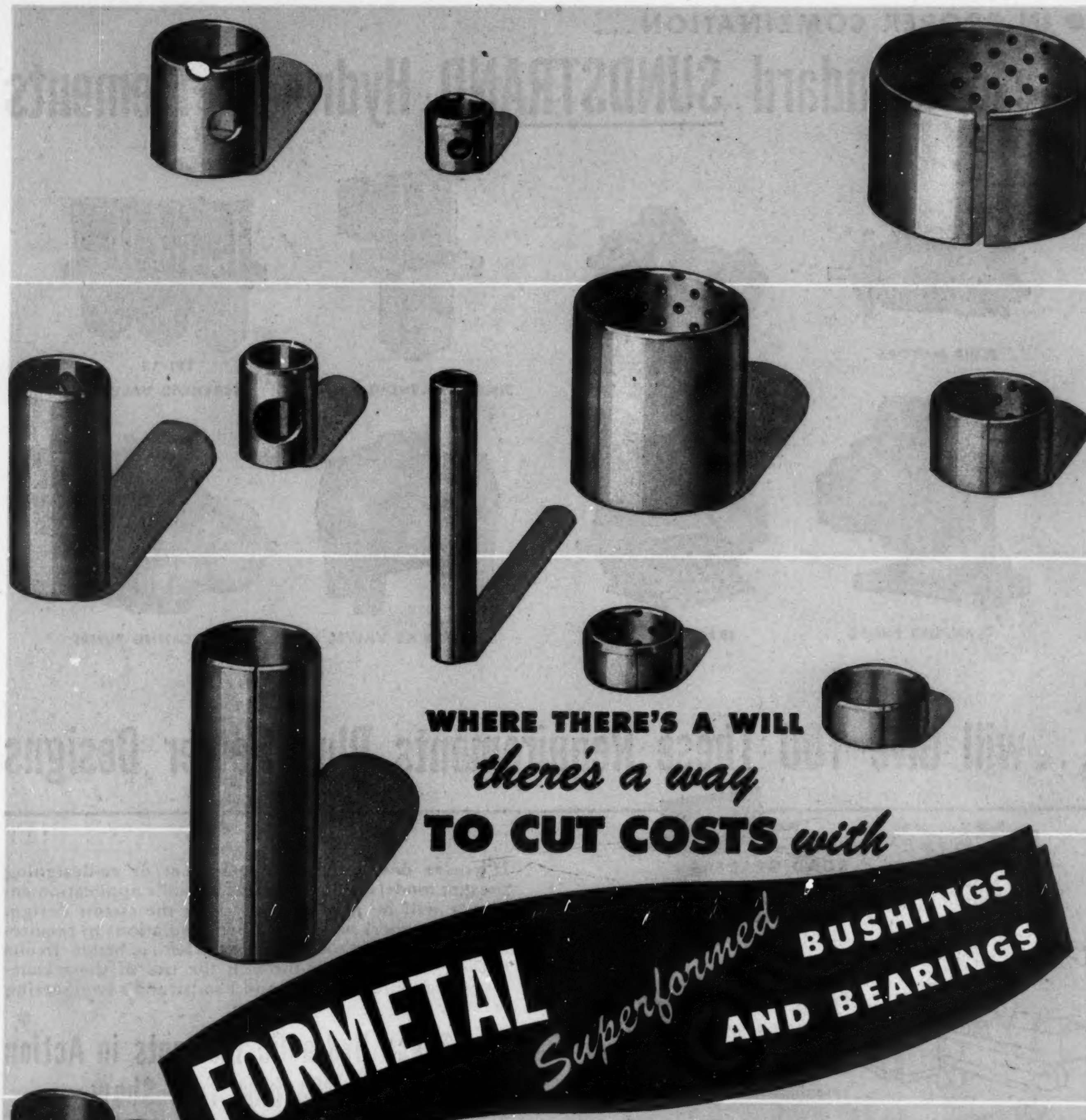
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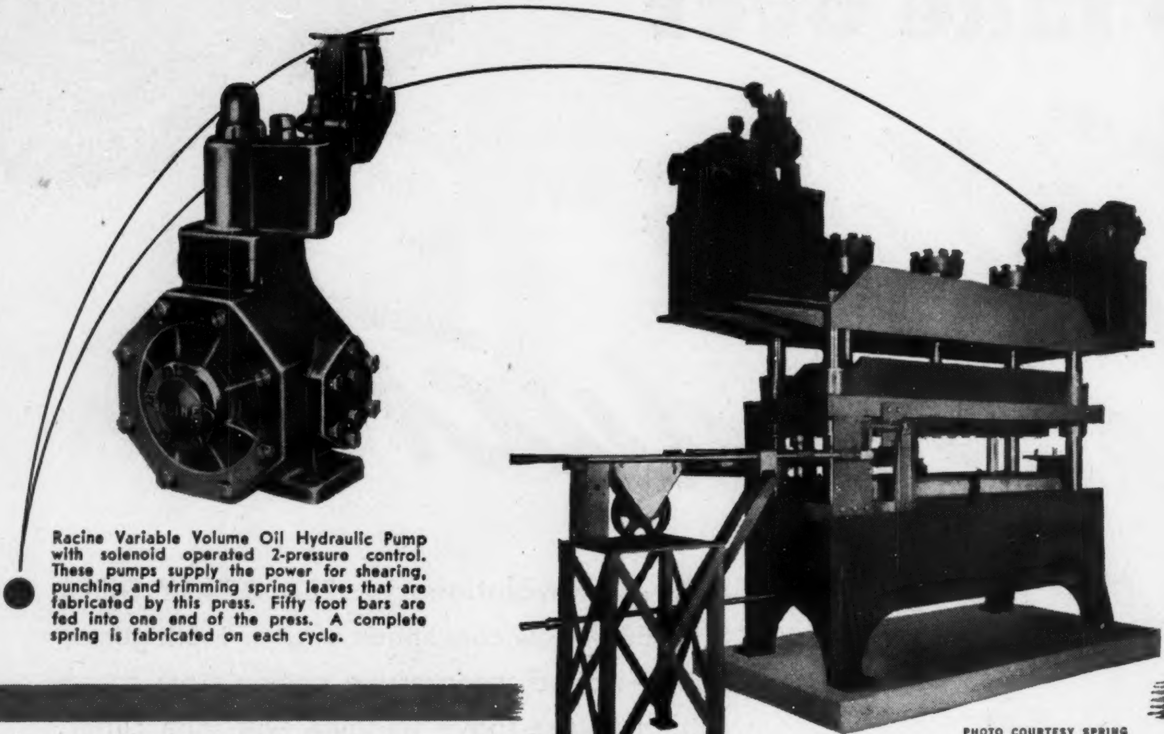

Racine Variable Volume Oil Hydraulic Pump with solenoid operated 2-pressure control. These pumps supply the power for shearing, punching and trimming spring leaves that are fabricated by this press. Fifty foot bars are fed into one end of the press. A complete spring is fabricated on each cycle.

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Smooth Oil-Cushioned Action Under Variable Volume Control

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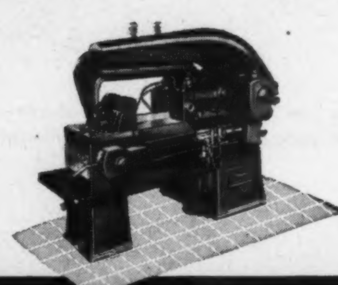

STANDARD FOR QUALITY AND PRECISION · RACINE · RACINE TOOL and MACHINE CO.

RACINE

STANDARD FOR QUALITY AND PRECISION

Topics

WORLD-WIDE STANDARDS of manufacture and testing would result in the development of a set of yardsticks whereby the standards of one country could be compared with those of another and expressed in definite numerical relationships. According to the General Electric Co. international trade in electrical goods is often handicapped because of the varying standards of the countries involved.

SOFT SOLDERING of aluminum can be accomplished by copper plating and then soldering in the usual manner. The copper should be stripped from the rest of the surface after soldering using chromic-sulfuric acid to avoid the corrosive hazard of a copper-aluminum couple. Aluminum can also be brass plated for bonding to rubber, chromium plated for resistance to wear or alkalies or zinc plated to prevent seizing of threaded parts, according to R. A. Ehrhardt and J. M. Guthrie in *The Monthly Review of the American Electroplaters Society*.

CERAMIC SPRINGS may have useful properties in special equipment. A research development at American Lava Corp. and made of steatite, these units have little "spring" but their factor of compression and expansion may prove valuable in some applications.

ENDLESS BELT of Type 302 stainless steel 36 inches wide and 0.30-inch thick has been produced by welding the joint with a tungsten electrode in argon gas atmosphere, with the thin sheets slightly overlapping at the start of the weld. The method was developed by General Electric welding engineers as an improvement over a straight butt joint, reducing distortion and providing adequate reinforcement without adding filler material.

INSTITUTE OF NUMERICAL ANALYSIS is being established at the University of California at Los Angeles as one of the newest units of the National Bureau of Standards. A high-speed electronic computing machine will be installed at the institute which will solve in minutes those problems which now take days and will solve in days those that are now out of reach. Design specifications call for high memory capacity and automatically sequenced mathematical operations from start to finish. The institute will do research in applied mathematics and also act as a service group for Western industries, research institutions and government agencies.

ELECTROLESS PLATING, a new method of plating nickel and cobalt on metal surfaces without the use of electric current, has been developed by the National Bureau of Standards. The process involves chemical reduction of a nickel or cobalt salt with hypophosphite in hot solution. The reaction is catalytic, and under the prescribed conditions of concentration and pH, no plating occurs unless certain metals are introduced in the bath. An adherent coating of 93 to 97 per cent purity is produced on the immersed metal.

MACHINERY MARKET for small-farm equipment will be one billion dollars annually for at least several years, based on a recent survey made by the Anti-Friction Bearing Manufacturers Association. A whole range of new, low-cost implements are expected to do for the one-man farm what the cotton picker is doing for the southern plantation.

NEW SYNTHETIC RUBBER, compounded by Parker Appliance Co., meets rigid tests for wear, heat and cold resistance, for physical properties and aging, and for precision manufacture. The synthetic was developed for O-ring packings and seals, meeting exacting Army-Navy specifications.

COATING FOR ALUMINUM and its alloys, either as a basis for paint or for protecting unpainted aluminum to be exposed in a corrosive environment, has been developed by the American Chemical Paint Co. Protection is generally equal to an anodic oxide coating or the oxide formed in the alkaline dichromate process. Time required for treatment is 2½ minutes.

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high dielectric strength

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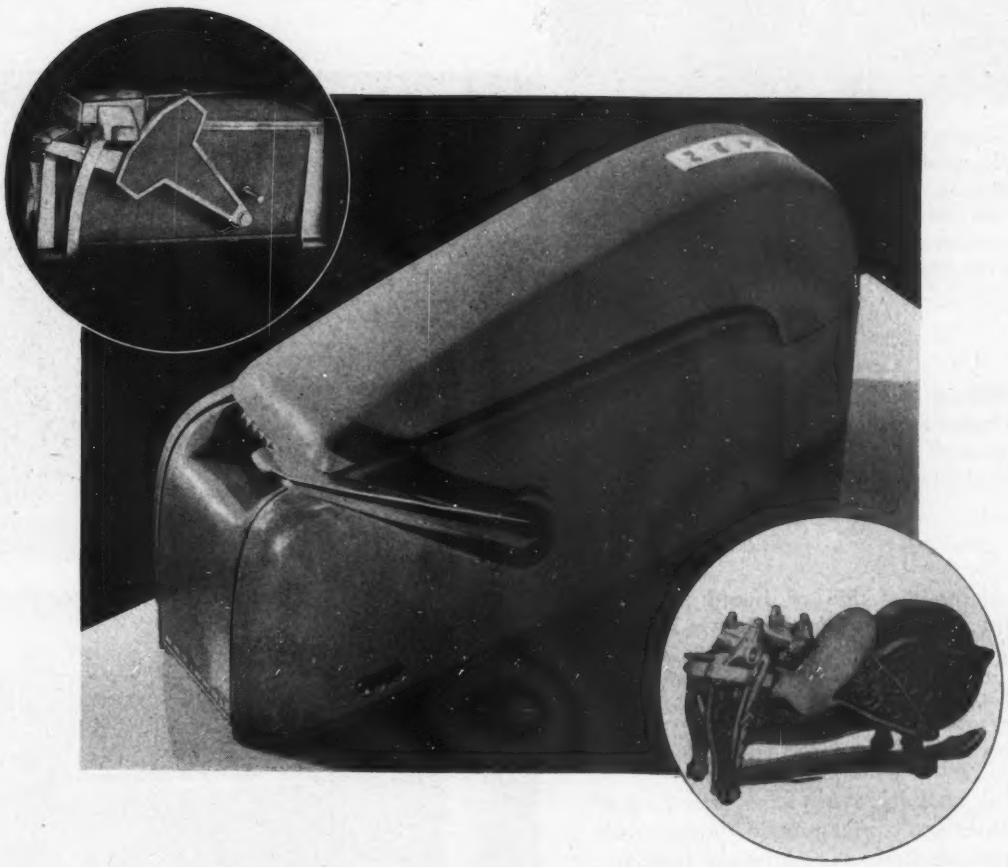
MACHINE DESIGN



Designing for Improved Appearance

By David F. Welch
Member of faculty, California Institute of Technology and Industrial Designer

Fig. 1 — Above — Progression in design of package sealer throughout the years. In most recent model, designed by Egmont Arens in collaboration with engineers of the Nashua Package Sealing Co., rhythmic relationships have been created by use of dynamic lines

AS COMPETITION increases in all branches of industry, more and more emphasis is being placed on appearance as an essential sales factor in machine and product design, *Fig.* 1. Hence it is only logical that everyone connected in any way with the field of design from the chief engineer to the detail draftsman should have an appreciation of aesthetics in relation to design. This will be of value to the chief engineer in working with the design consultant as well as to his entire staff in the promotion of better design. The purpose of this article is to better acquaint the engineer with the design process from the industrial designer's point of view and with the basic factors which must be considered in appearance design.

Sales value of appearance relative to cost, performance, and the expected life may

Fig. 2—Above—Texture of black wrinkle finish has been functionally used on this typewriter to reduce glare. Dust-catching areas are covered or eliminated and a thin chrome strip covers the parting line between cover and frame. Designed by Henry Dreyfuss for the Royal Typewriter Co.

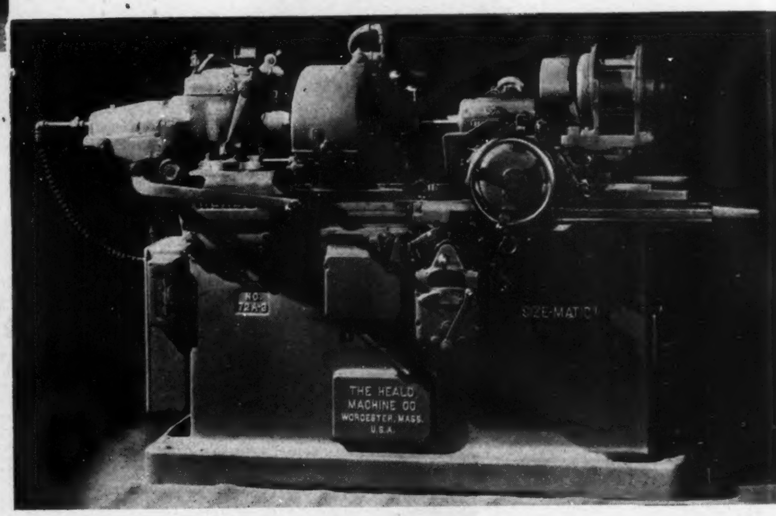


Fig. 3—Right—Internal grinder before redesign (Fig. 4) presented conglomerate mass of mechanism and controls suggestive of complexity and difficulty of operation and maintenance

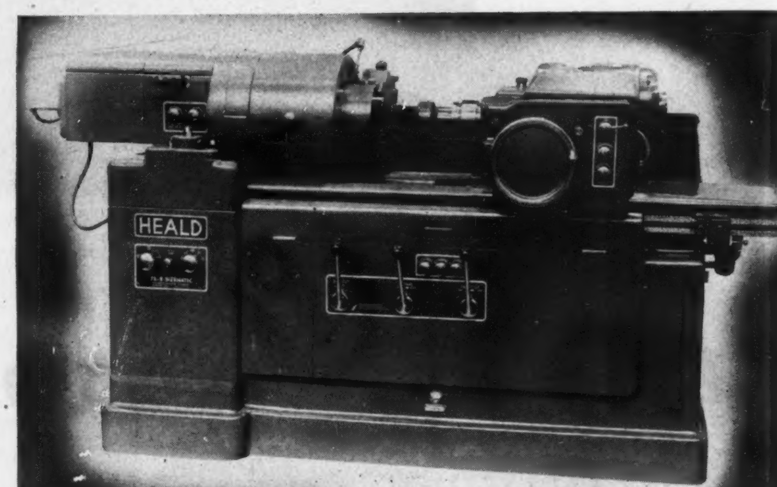


Fig. 4—Right, below—Redesign of Heald Machine company's internal grinder by Walter Dorwin Teague entailed logical grouping of controls, greatly simplified form and use of removable housings and cover plates to facilitate cleaning and maintenance

vary considerably in different machines and in similar machines in different price ranges. Appearance in highly competitive items may in many instances be solely responsible for attracting attention, creating the desire and consummating the sale. Among expensive appliances, such as washing machines, stoves and refrigerators, where the consumer is in reality making an appreciable investment when purchasing, maximum utility, efficiency and guaranteed performance play a relatively more important part than in inexpensive items. However, appearance still may outweigh these other factors, particularly where the final choice is made by the feminine consumer. The design in this case must meet two criteria: First, it must look more attractive than a competitive model on the sales floor and secondly, it must be appropriate in its surroundings—the user's home.

Styling should not be carried to the extent that a machine may become objectionably dated in appearance after serving only a small part of its useful life. Office, scientific and industrial equipment demand the most conservative treatment. Here function and cost are of primary importance but appearance still plays an important role in competitive selling. Exemplification of these considerations is found in the modern typewriter, *Fig.* 2. The designer must constantly keep in mind that the consumer will be living with his designs, and they should be not only well engineered but also pleasing aesthetically. They must not be designed merely as eye catchers on the sales floor which soon turn out to be eye-sores in the factory, office or home.

Good appearance design is largely a product of the individual designer's insight into the specific problem, his own critical ability, and his appreciation of potentialities in new materials and fabrication techniques. Without highly developed aesthetic judgment and critical ability it is obvious the designer would never be able to improve his own first sketches, let alone approach to any degree a theoretically ideal form. Aesthetic judgment seems to be a quality possessed by many persons in varying degrees, yet one which seems to be totally lacking in others. Even with a faculty for this judgment or critical ability, it can be developed further only over a long period of time after intense study and broad experience, preferably under the guidance of various trained designers and not under one individual. It cannot be accomplished through study alone. The design considerations presented in the following discussion are only to be considered as a guide in objectively analyzing or criticizing design, and it should be emphatically stated that there are no laws or sets of rules which should be or can be followed implicitly in designing

a thoroughly satisfactory, attractive machine.

THE BASIC FORM: The first step in the development of any new design should be a highly critical analysis of all functional aspects of the desired machine. Next, a purely theoretical "ideal machine" should be visualized as one which will perform all these functions to perfection and yet one which the designer may only expect to approach in actuality. This step can be entirely a mental process and yet will often help to suggest the most direct and fundamental approach to the problem. Before proceeding with preliminary sketches, the designer should make a comprehensive study of any available information on competitive machines, related patents and the problems of marketing the specific machine.

With as complete a background as time permits the designer may proceed with his sketches and preliminary layouts. In this stage of design the basic form begins to take shape. By the term basic form is meant the grouping or organization of all structural elements and moving parts in such a manner that there results an efficient working model of the mechanism or machine. As further improvements are made in relation to the utility, safety and maintenance of the machine, this basic form will undergo minor changes and refinements. Still additional changes may be made in the final selection of materials and simplification of the manufacturing processes. Actually all these factors are synthesized in the designer's mind as he makes his first sketches. The quality of his basic design will depend largely on his own creative ability, his background of knowledge, and the amount of time available. Again, in actual practice a whole design group may be working on the particular project and, if properly guided, the final design is likely to be superior to that conceived by any one individual.

UTILITY: It has been stated that function in terms of utility, safety and maintenance plays the major role in determining the basic form. A simple illustration will serve to further clarify this statement. An excellent example of how utility may affect the basic form may be seen in one of man's oldest and simplest tools, the hammer. In a very general sense the principal use of the hammer is as an implement for pounding or striking. It consists of two principal parts: The head or weighted striking surface, and a handle or lever arm to provide a mechanical advantage. Consider next the many specialized uses of this simple tool, a few of which are pounding stakes, driving spikes, forging steel, hammering and pulling nails, forming sheet metal, and planishing jewelry. In each case the specific use demands an entirely different basic form. The sledge hammer, the claw hammer, the ball peen, and the tiny planishing hammer all have different forms, each determined by the consideration of maximum utility for its special function. Within each of these categories there are also many variations in shapes, sizes and materials each designed for its specific purpose. It is important to note that each hammer is a really beautiful tool only when its basic proportions are carefully refined and its surface nicely finished in production. This example may serve to illustrate the infinite number of variations possible in the basic form of a more complex machine.

Fig. 5—Below Portable sales register by Walter Dorwin Teague in collaboration with engineers of Moore Business Forms, Inc. It is a trim, convenient-sized hand machine finished in two tones of gray, with zinc die castings to house the forwarding mechanism. Bright red pushbutton adds dash to the sleekness of chrome-plated surfaces

SAFETY: Safety, as the next essential consideration in design, may affect the basic form by necessitating heavier structural bracing or the addition of covers and guards to enclose exposed moving parts, gear trains or electrical circuits. Bumpers on automobiles, guards on machinery, and covers on switch boxes all are essential primarily for safety reasons and all affect the appearance of the basic form.

MAINTENANCE: The maintenance factor may have a much less obvious effect on the basic form but often necessitates extra handles, exposed fastenings and additional breaks in the surfaces or covers of the basic form. The automobile hood, removable covers and plates on machine tools or motor housings, all cause slight variations in the original form. In redesigning the internal grinder, *Figs.* 3 and 4, maintenance was an important consideration, resulting in strategically placed removable cover plates.

COST, MATERIALS AND FABRICATION: Although cost may be rated as of secondary importance in our discussion of factors influencing the appearance of our basic form, it is certainly of paramount importance to the manufacturer. Actually the effect of cost on the form is indirect but, assuming the functional aspects are all provided for, cost often may dictate the use of certain materials and certain methods of fabrication which may also affect changes in form. The automobile wheel is an example of a comparatively simple unit the function of which on a 1947 model is much the same as on a 1917 model; yet its appearance has been considerably changed with the use of different materials and techniques in manufacture. The modern formed disk wheel is certainly cleaner in appearance, cheaper to produce and stronger than the old wire wheels and the earlier wood-spoke wheels. Here a different material, used to perform the same function, has necessitated a change in form and provided a better wheel at lower cost.

Advances in manufacturing techniques have brought about the simplification of many production problems and in turn have helped to lower costs. Die casting has made it possible to produce in large quantities rather complex housings for items such as business machines, sewing machines and other household appliances at a great saving in machining time. A good example is the sales register

of *Fig.* 5. Progress in sheet metal forming, furnace brazing and spot welding has in turn brought about the redesign of many articles formerly made as heavy castings. In each case of redesign some modifications of the original basic forms is required.

Refinement of the Basic Form: So far the discussion has been centered on the way in which utility, safety, maintenance, choice of materials, and manufacturing costs enter into the problem of determining the basic form. Now assuming a basic form has been logically developed, further refinement of this form from the appearance standpoint is necessary. As an introduction to this phase of design the following outline will give an integrated concept of the ideas to be presented.

Inherent Qualities in Aesthetically Satisfying Form

A. Unity
  1. Simplification of Form
  2. Proportional Relationships
  3. Repetition

B. Interest
  1. Emphasis
  2. Contrast
  3. Rhythm

C. Balance
  1. Symmetry
  2. Asymmetry

Further Enhancement of Basic Form Through Surface Treatment

A. Color

B. Texture

C. Quality

These requirements or qualities are inherent in all good design. They cannot be considered as complete within themselves nor are they to be used as a list of requirements which must be conscientiously met step by step in developing a design. They are merely a list of various qualities which have been recognized by many art critics and philosophers as essential elements in all truly great works of art and architecture of the past and present. They may be of value to the industrial designer only as a possible check in the critical analysis of design and not as a set of tools. Perception based on sound training in the arts will be the only real guide in the formulation of good design.

Unity: Unity is probably the most important single requirement of any form which is to be aesthetically pleasing. The term unity will be used to imply an orderly, consistent and harmonious relationship between all portions of the form as a whole. A form which lacks unity, one whose various elements seem to have no relationship to each other or the form as a whole, is disturbing. The analytical observer may recognize this disharmony as such and understand his negative reaction to the form while the casual observer may merely dislike the form without understanding the reason. Most of us derive certain satisfaction conscious or otherwise when we can readily perceive relationships. In such a complex and busy age, easy perception of unity, order and relationships may act as a tonic to counteract some of the many disharmonies in daily life.

Simplification often effects the most dramatic modifications of form in the struggle for unity. The typewriter, the electric motor, and the automobile, *Fig.* 6, are all excellent examples of inventions which were first produced as rather confusing masses of functional elements when judged from an aesthetic point of view. Each of these today has been greatly simplified in form and is not only more serviceable functionally but more pleasing visually.

Effects of Proportional Relationships

Proportional relationships are another primary factor to be considered in connection with unity. The basic form as it was conceived originally often may be modified to give more pleasing proportional relationships without seriously affecting any of the functional aspects. The overall length, width and height ratios may be improved in a simple housing or rearranged in certain cases where the appearance can be improved. Proportional relationships as they affect the unity of the whole are particularly important in the design of covers, housings, and structural supports. The Greeks were particularly conscious of proportion in their art and architecture, carefully planning the basic form or structure as well as the proportions and relationship of every element in it.

Scale, another element, may be considered in conjunction with proportion. Scale is used in the sense of size relationship. For example, an attractive nameplate of a certain size may definitely enhance the beauty of a particular unit while a small one may look like an afterthought and a larger one may overpower the over-all design. A simple chrome strip correctly handled often may become an asset to the design as well as covering up an unattractive parting line. Scale is of utmost importance in details such as chrome trim, scored lines or integral bands which are devices too frequently used only as decorative elements.

Repetition is an extremely valuable aid in the further

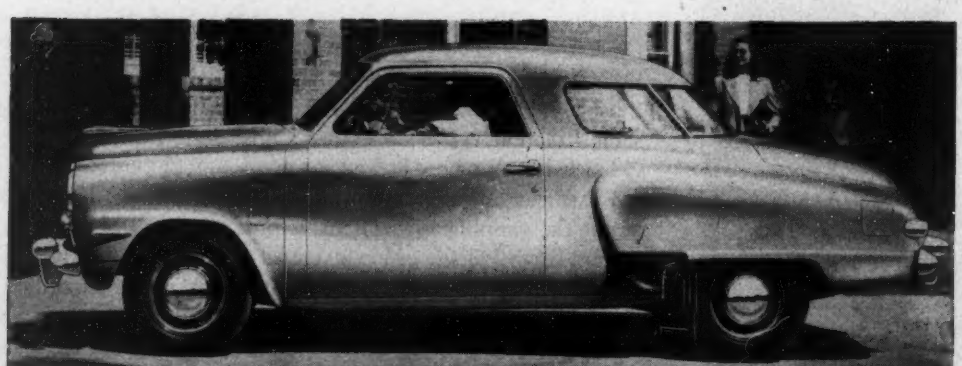


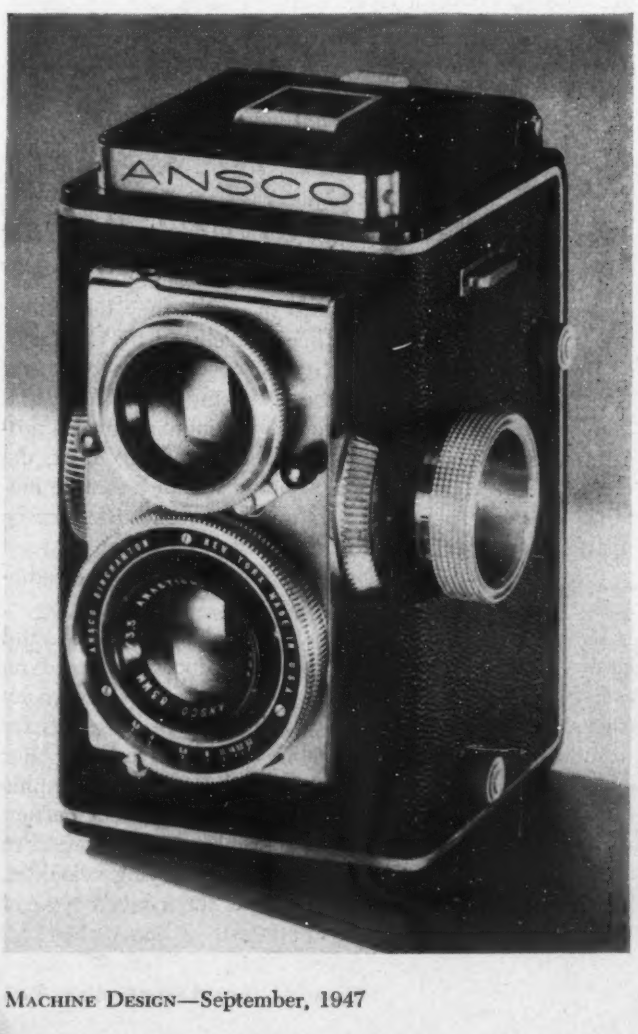
Fig. 6—Studebaker 1947 Champion coupe; body styling by Raymond Loewy Associates. Additional roominess and better visibility were two objectives in this design. This model probably is the harbinger of new trend in the highly specialized field of automobile styling

unification of any design. Certain characteristic lines, surface contours, fillets and radii or sometimes even forms repeated appropriately throughout the basic form will aid immeasurably in the refinement of a unified and coherent design. Repetition must be used logically and carefully so that it gets neither ridiculous nor monotonous.

INTEREST: Interest is used to imply that vital quality of a design which may attract and stimulate attention. Through emphasis on certain elements in the design and subtle variations in others, an interesting rhythmic pattern can be established which the eye will unconsciously follow as it scans the form. A logical center of interest such as the instrument or control panel on a complex machine should be emphasized in contrast to other less important elements in the form. This center of interest will help hold the design together by continually drawing attention back to the point of emphasis as each element of the design is examined. Note how, in the camera of *Fig.* 7, attention is focused on the most important element, the objective lens.

BALANCE: Balance along with unity and interest must also be considered in the study of form. In general there are two types of balance, classical or symmetrical balance, and the more dynamic asymmetrical balance, the latter be-

Fig. 7—Below—In this Ansco reflex camera designed by Henry Dreyfuss, attention is focused on the most important element, the objective lens. Texture, used functionally to insure good grip, also provides interesting contrasts between pebbled, knurled and polished surfaces



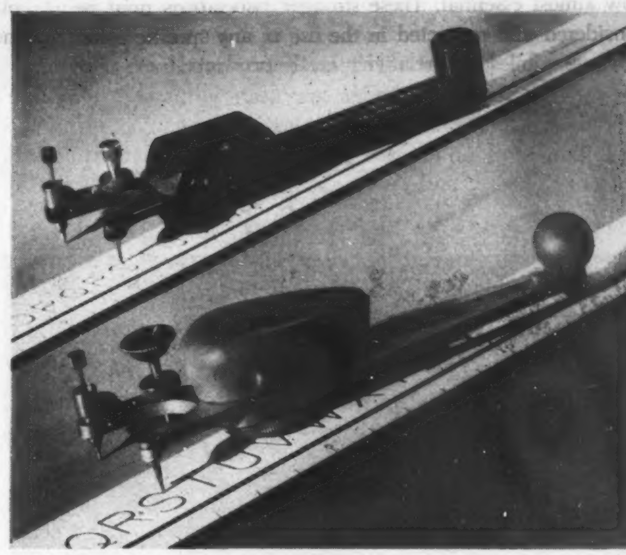


Fig. 8—Leroy lettering scriber redesigned by Francesco Collura for the Keuffel & Esser Co. presents a dynamic assymetric balance. More comfortable finger grip, lighter construction and improved appearance are features of redesign as compared to former model shown at top

ing illustrated by the lettering scriber of *Fig.* 8. Apparent stability as well as visual balance are both important factors in the design of all forms. An electric fan or a kitchen mixer may have sufficient stability with a weighted base from the standpoint of mechanics and yet not be visually acceptable because it looks as though it might tip over. This is the more obvious aspect of balance or stability. The other equally important aspect is that of visually balancing different masses in the basic form. Various elements of a form may be balanced about an axis of symmetry in certain cases like the airplane or may be balanced asymmetrically as in the case of milling machines or turret lathes. In nearly every case the type of balance, symmetric or asymmetric is determined by the function alone.

SURFACE TREATMENT: In addition to the qualities of basic form which have been discussed so far, there are other very important aspects which have a definite bearing on the aesthetic appeal of a finished machine. These relate principally to the surface treatment and must be carefully co-ordinated to further enhance the refined form. First in importance is color. Color is probably the simplest and most effective aid which can be used superficially to help unify a complex form. A single color applied to the entire surface of a form has a very powerful affect on the unity of the design.

There are many aspects of color which should be considered in machine design. The average consumer has strong psychological associations with certain colors which must be recognized. For example, the association between the color red and danger has come down through the ages perhaps from primitive man's first sight of his own blood or perhaps from the embers of a burning fire and must be used carefullly in design. Small quantities of red can be used very successfully in attracting attention to important control knobs or name plates and in adding interest to the form. The color white has been associated with sanitation so long that its use on refrigerators, kitchen stoves and food processing equipment is

now almost essential. These stronger associations must be considered and respected in the use of any specific color. On automobiles and relatively costly products, more conservative tones and shades are used with a rather wide choice to suit the individual tastes of many consumers. Machine tools and office equipment are usually finished in tones of gray and conservative dark colors to be as unobtrusive as possible. Color should be used functionally. It may be used to enhance the beauty of a product, to attract attention, and to increase safety and efficiency.

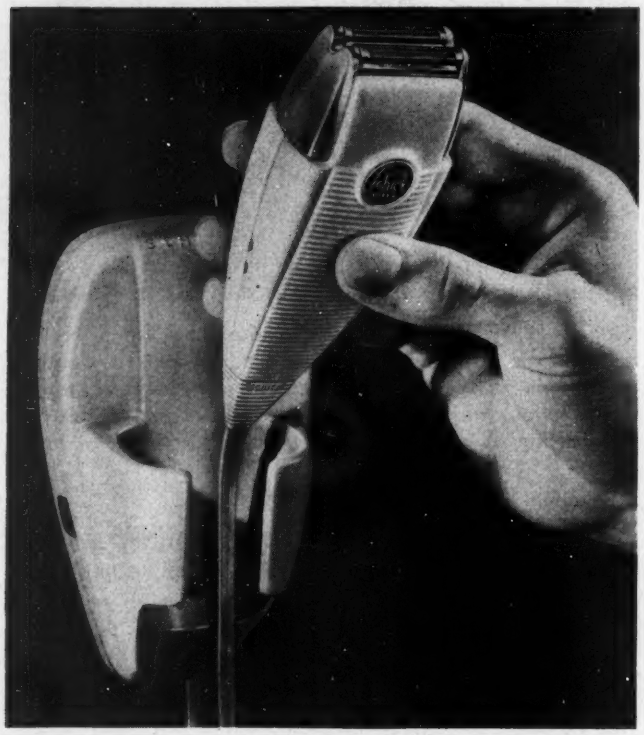


Fig. 9—Ribbed texture of Schick shaver designed by Raymond Loewy Associates provides secure and comfortable grip as well as an interesting motif in its symmetrically balanced design

Texture may be used very effectively to provide interesting contrast between various surface areas. Reference is here made to texture as a surface or tactual quality such as roughness, smoothness, softness, hardness, coolness and warmth. Surface texture may achieve pleasing contrasts as between the roughness of a wrinkle finish and the smoothness of a polished surface. Texture may also be a functional asset in a design, as in the electric shaver of *Fig.* 9. The typewriter is an excellent example of how a wrinkle finish may be used to reduce the fatiguing glare of reflected light and the hand stapler still another where it is used to provide additional traction on a hand grip.

Quality of finish is of great importance in judging the appearance of many products. Much of the aesthetic appeal in scientific instruments, guns, and small tools lies in the craftsmanship and perfection of finish the object is given. Flawless finishes and matching parting lines are expensive and usually impractical in low-cost, mass-produced products. There are, however, many devices used to cut down this expense, including the application of wrinkle finish on relatively rough surfaces, the use of offset parting lines and the addition of chrome-plated beading to cover up unattractive seams in sheet metal products.

Summarizing the discussion of appearance design, it has been shown that the first step should always be the development of a basic form, which is finally conceived after a thorough consideration of functional requirements, costs and marketing problems. This basic form is then refined and further enhanced through various subtleties and surface treatment. The obvious advantages of considering appearance along with function, the choice of materials, and fabrication methods in the very first design sketches are still too seldom recognized. To accomplish this in practice we must either have a design engineer who is also extremely capable in appearance design, an industrial designer well versed in engineering, or we must call in the industrial design consultant. There are many instances where the industrial design consultant is retained by the manufacturing organization and can, therefore, be of maximum value as new machines are developed. With a broad background of experience gained through working with many different organizations, the consultant often is also able to contribute ideas which are often overlooked by those connected only with the one program.

There is little doubt that slightly increased development costs can be more than offset by an increased volume of sales resulting from a more attractive machine on the market and in many cases this improved design will actually cost less to produce. The alert designer often can effect savings by suggesting a substitution in material or technique in manufacture. Certainly the aim of every designer should be toward the simplest possible solution of each new problem with the objective of helping to provide the consumer with a more useful, a safer and a more attractive machine at a lower cost. In attaining these objectives the designer will also be helping to increase the manufacturer's profits by creating added sales acceptance of, and good will through each new design.

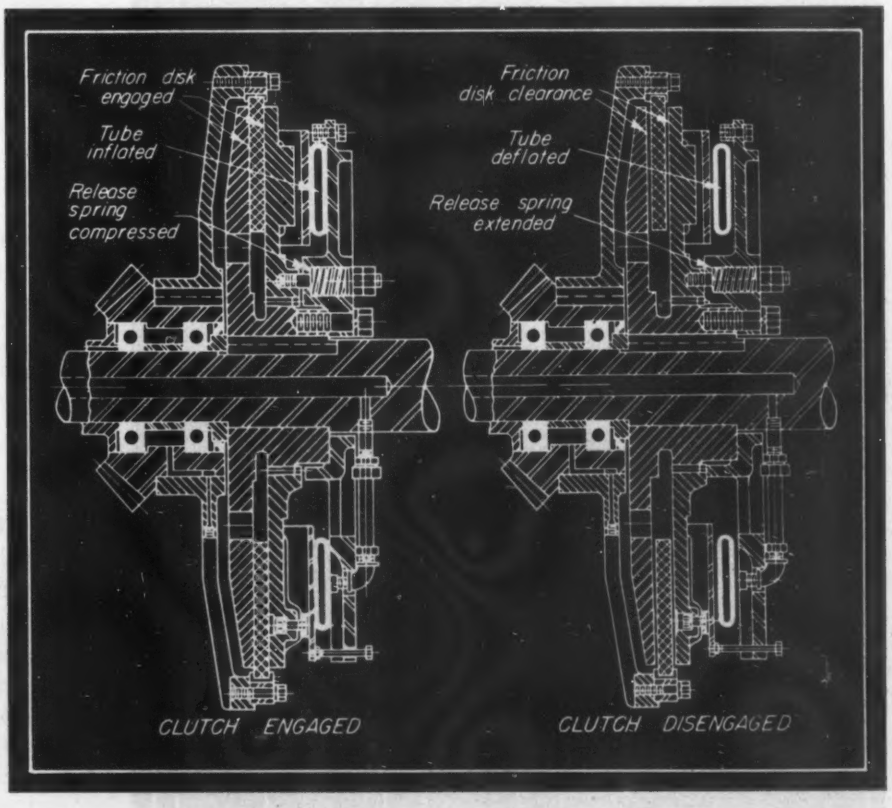
Isotopes Detected by New Method

A NEW method for more effective tracing of radioactive isotopes in materials in which they have been intentionally introduced has been developed by L. Martin of the National Bureau of Standards with the co-operation of P. H. Abelson of the Department of Terrestrial Magnetism, Carnegie Institute of Washington. In this procedure, by means of a magnetic focusing arrangement, the radiation given off by a radio-isotope within a sample material is made to form an image of the emitting surface upon a photographic plate. The image may then be used in studying the distribution and concentration of the radioactive element present in the sample.

Used in friction studies and other fields of research, and known as "tracer micrography", the process is based on the emission of high-speed electrons (beta rays) by many tracer elements and the use of magnetic lens elements for forming an image on a suitable recording surface. For calibration of the instrument employed, the photographic film is replaced by a Geiger counter, and the lens current necessary to produce a maximum number of counts in unit time is determined for radiations of varying velocities. This establishes the focusing current for a given type of radiation.

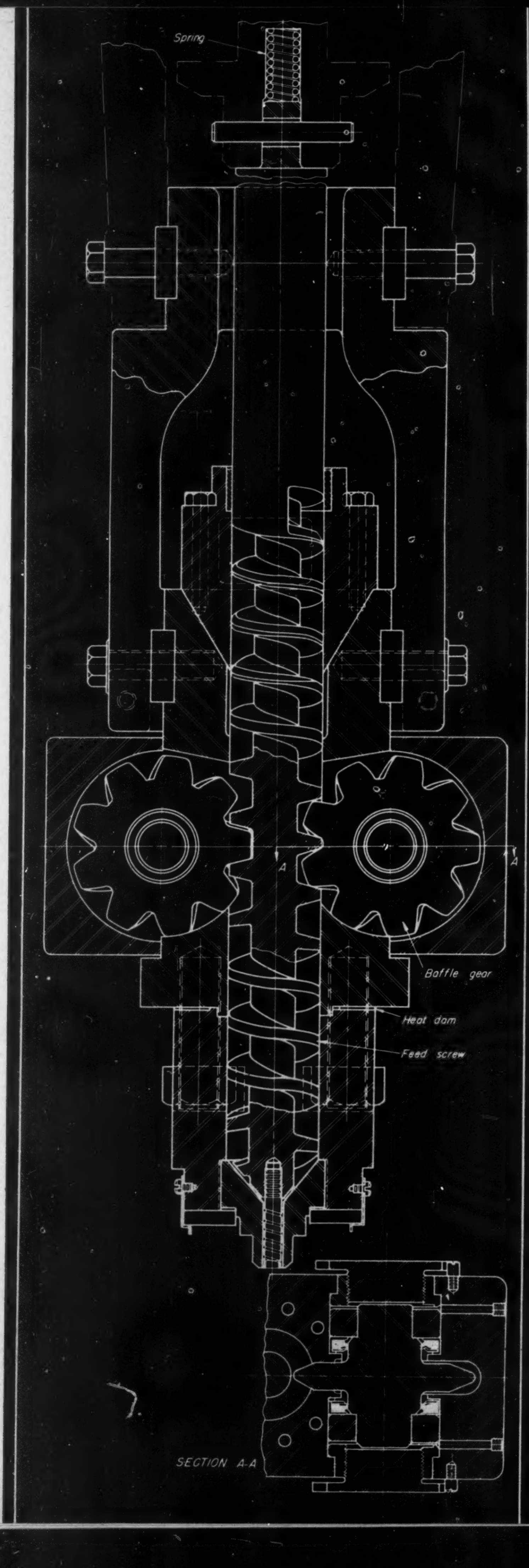
Scanning THE FIELD *for Ideas*

AIR-POWERED clutch, below, designed to give operator "feel" of engagement at the controls and to preclude a jerky or too fast engagement, utilizes a circular tube or "doughnut" for actuation. This tube is made of rubber and is confined between two plates, one of which is movable. When air is admitted under pressure, the tube expands and clamps the friction disk between the floating plate and the back plate of the clutch. By means of metering valves, the pressure can be varied at will of the operator, and the load can be picked up as slowly or as quickly as the operator desires yet, due to the volume of air required, it is impossible for the operator to admit air fast enough to cause the machine to jerk. Levers, pins, collars and other working parts usually employed are obviated. In this clutch, designed by the Osgood Co., the only part that receives considerable wear is the friction disk which is easily replaced as a single unit. The rubber tube also is readily replaced.



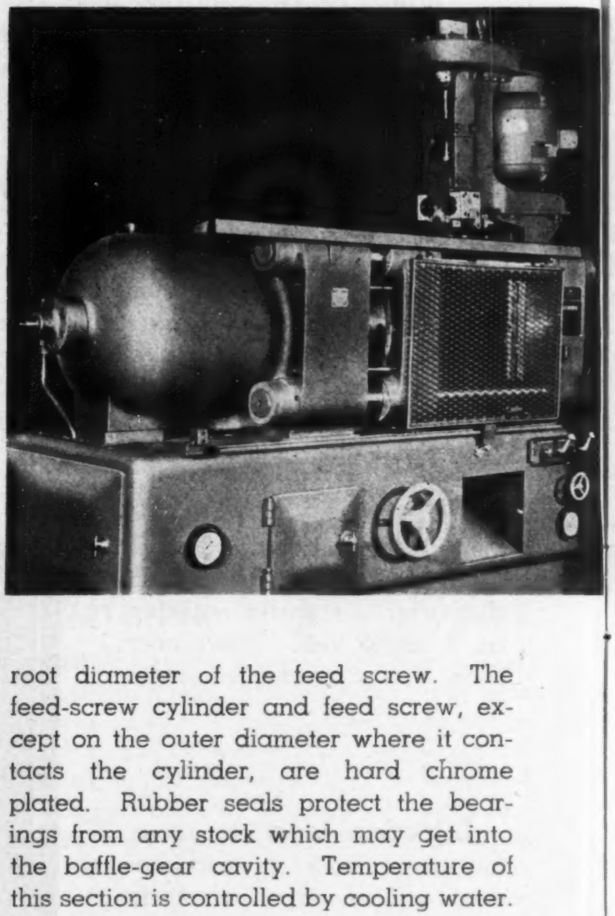
Injection feed for rubber, illustrated both in sectional view and in use on a rubber injection molding machine on the next page, utilizes a motor-driven screw and baffle gears. These gears serve to prevent the stock from turning with the screw and to provide a pressure lock, preventing the rubber from leaking back past the baffle after it has been forced into the injection chamber. Designed by Hydraulic Press Mfg. Co. in co-operation with Chrysler engineers, this mechanism receives material in rod, strip or pellet form near the top of the feed screw where it is taken into the convolutions of the worm by a masticating action, heating the material by friction and further working it. The material thus being worked is split into two halves by the baffle gears, involving more turbulence and more heating. Once past the baffle, the two halves unite and fill the space between the threads of the worm. Heat is put into the material during the rest of its travel in the mechanism.

When the end of the feed screw is reached, the material is filmed over the conical end of the worm, which floats against a spring at its other end, and is forced through the nozzle into the mold. When the mold is filled and the injection unit backed off the pressure is locked in the chamber between the



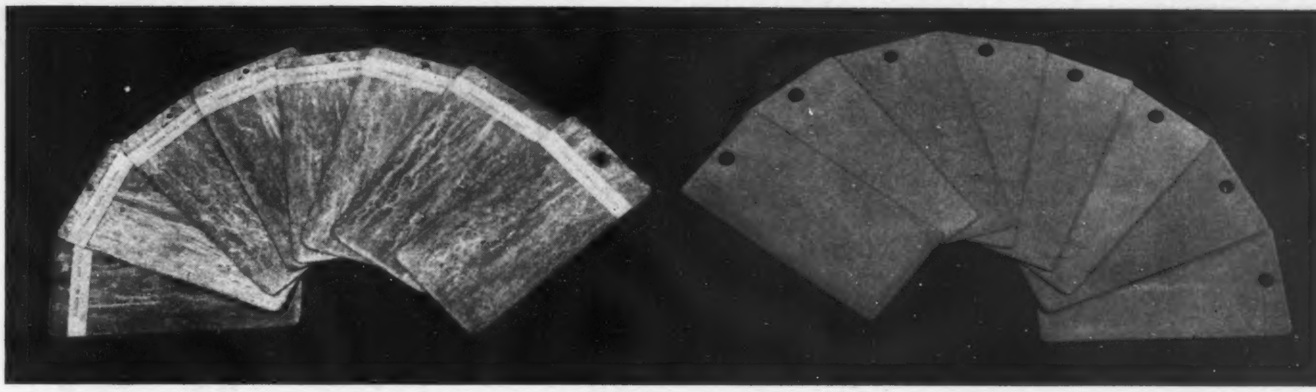
baffle gears and the end of the worm by the spring seating the worm against the nozzle.

Baffle gears are hardened die metal and are free running in precision sleeve bearings. These bearings provide a support to the gears against the thrust of the feed screw and give the alignment necessary to keep the gears from binding. The gears are of special left-hand helix design to provide maximum filling of the space between the feed-screw teeth which are in the shape of Acme threads at the point of meshing with the gears. When a gear is in full mesh there is 0.0035-in. clearance between its outside edge and the

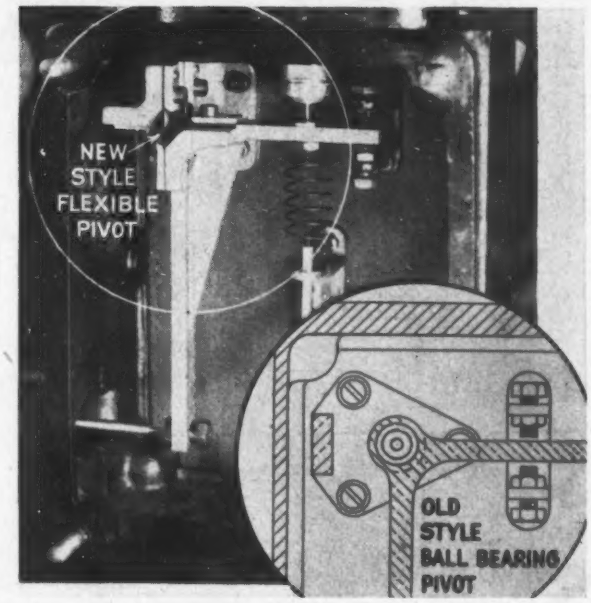


root diameter of the feed screw. The feed-screw cylinder and feed screw, except on the outer diameter where it contacts the cylinder, are hard chrome plated. Rubber seals protect the bearings from any stock which may get into the baffle-gear cavity. Temperature of this section is controlled by cooling water.

Protective zinc coatings, applied by brushing, dipping or spraying, are relatively unaffected after 1000-hour exposure in standard salt-fog corrosion equipment as shown in the illustration at top of next page. Right-hand group of test panels shows coating before test, left-hand group of panels shown is after test. Known as Zincilate, the coat-



ing was developed by the Commonwealth Engineering Co. for Industrial Metal Protectives Inc. and has been used successfully on machine parts, tanks and marine equipment. Applied in one coat and dried by infrared, baking, or induction heating, it possesses high abrasion resistance. As with other zinc coatings, when areas are destroyed, cathodic sacrifice of adjacent film protects the parent material.



Flexible pivots of spring steel are utilized for the transmission of impulse signals in lever systems for bellows, diaphragms and bourdon tubes in Askania Regulator Co. instruments. Shown at right is a flexible pivot as well as a drawing of a conventional bearing which the new design replaces. The new style pivot is rigid in itself and can be mounted in any position. Because the total motion of the lever is small—only a few degrees—the spring characteristic is linear and for most applications is negligible. The design avoids troubles to which corrosion, dirt or poor lubrication expose ball bearings, pivots or shafts.

Hot-cold pipe, shown at right, converts ordinary compressed air into both hot and cold air without the aid of moving parts. It is thought that the phenomenon may be caused by frictional effect between gases moving at different velocities. Compressed air is pumped into a nozzle at one end of the 1-inch diameter pipe where the air strikes the inner wall tangentially to the diameter and is converted into a whirlpool. Cold air is drawn off through a ¼-hole hole in one end while the hot air is tapped from the periphery. Built by Westinghouse, the tube gives a temperature differential of only several degrees because of the relatively large diameter necessary for study with instruments. The original 0.3-inch diameter tube, invented by a German, produced jets at 10 and 154 F.

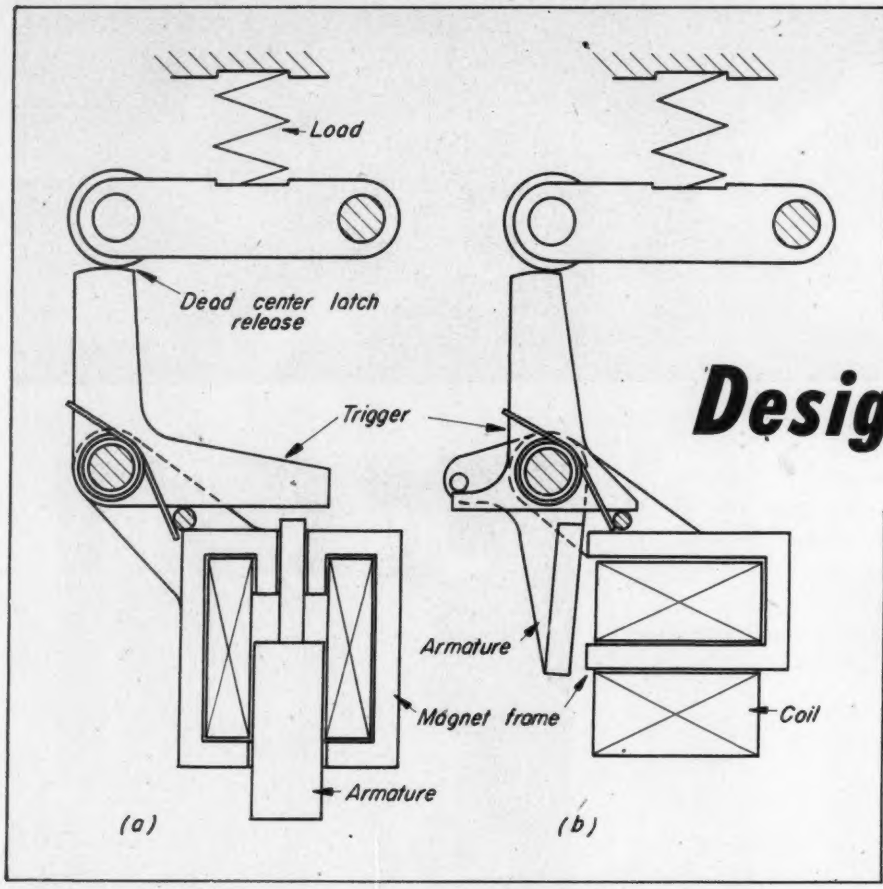


Fig. 1—Left—Two common types of armatures, for actuating latch releases, are the plunger type a and the clapper type b

Designing Quick-Acting

By Carl Thumim

Chief Engineer
Special Products Division
I-T-E Circuit Breaker Company
Philadelphia

SPEED of response of any latched mechanism, for example a circuit breaker, depends on the method of latch release as well as on the design of the latch. The latter is well known and has been classified into several main types*, the most important being (1) dead-center, (2) over-center toggle, (3) over-center surface, and (4) magnetic. Their characteristics, methods of analysis and of design are well known and need not be further discussed.

* "Characteristics of Release Latches"—Carl Thumim, *Machine Design*, Jan. 1940, p. 58.

Methods of releasing latches, of rapidly releasing them and of stabilizing them to withstand shock, on the other hand, are of interest at present. Considerable work has been done in recent years in working out methods of latch design to withstand enormous shock due to gun-fire and near misses.

Latch Tripping Methods: To obtain high-speed operation, latches are usually set in motion by electrical means, although other actuating schemes are not altogether ruled out. The simplest apparatus is a solenoid provided with a movable armature. When the coil is

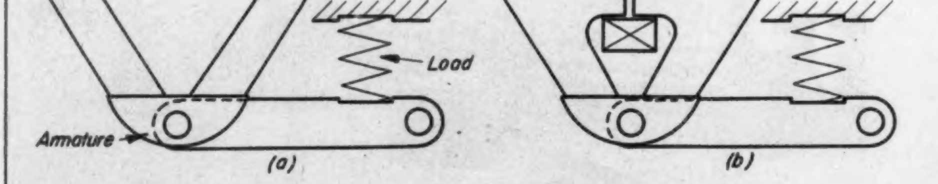
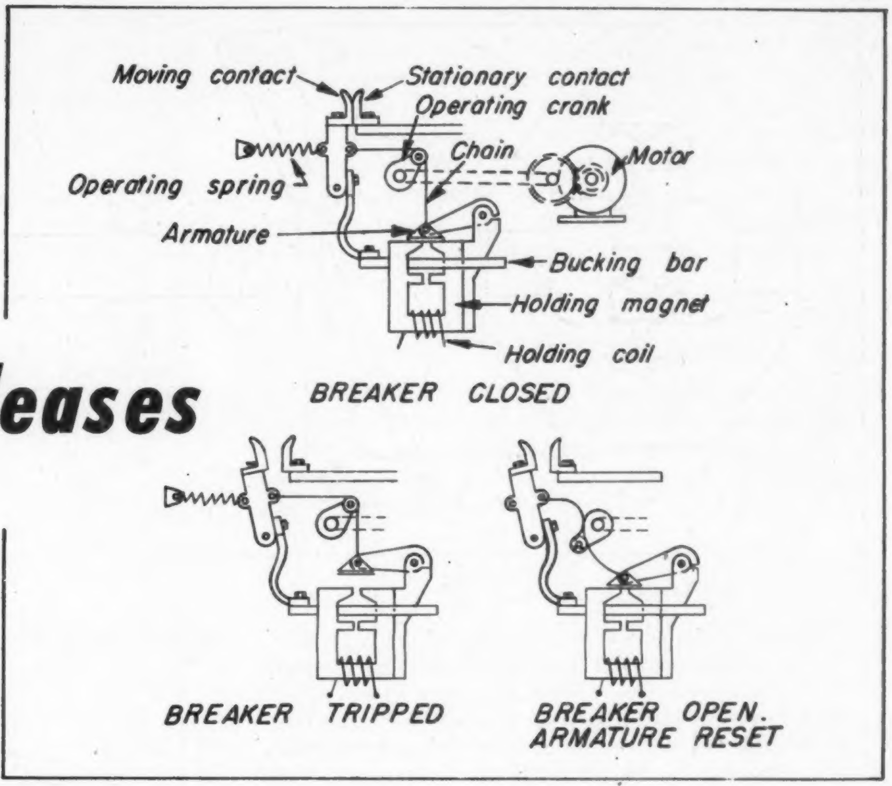


Fig. 2—Left—Speed of latch actuation is improved by employing the flux shifting type b rather than the simple electromagnetic type a

Fig. 3—Right—High-speed circuit breaker which utilizes the flux shifting type electromagnetic latch release



...ting Latch Releases

energized, the armature moves and releases the latch. Two types of armature are common, one being a plunger, *Fig. 1a*, and the other a clapper type, *Fig. 1b*. By regulating the distance of the armature from the pole piece or by changing the tension on a spring, the value of the pickup current can be set. Where high speed is required, an external device such as a relay determines when tripping shall occur and it then impresses full voltage on the tripping coil and causes the most rapid action. The speed of response depends on the constants of the coil circuit and must be determined according to the principles outlined in the following:

1. Sufficient accelerating force must be supplied to the latch by the trip coil armature to effect action under the most adverse conditions of load, friction and voltage. This force varies with the ampere turns of the coil.
2. The force available for each unit of armature face area varies as the square of the lines of force, up to the saturation point. Thus, below saturation, if the area of the armature is reduced to one half, with the same total number of lines of force, the force exerted by

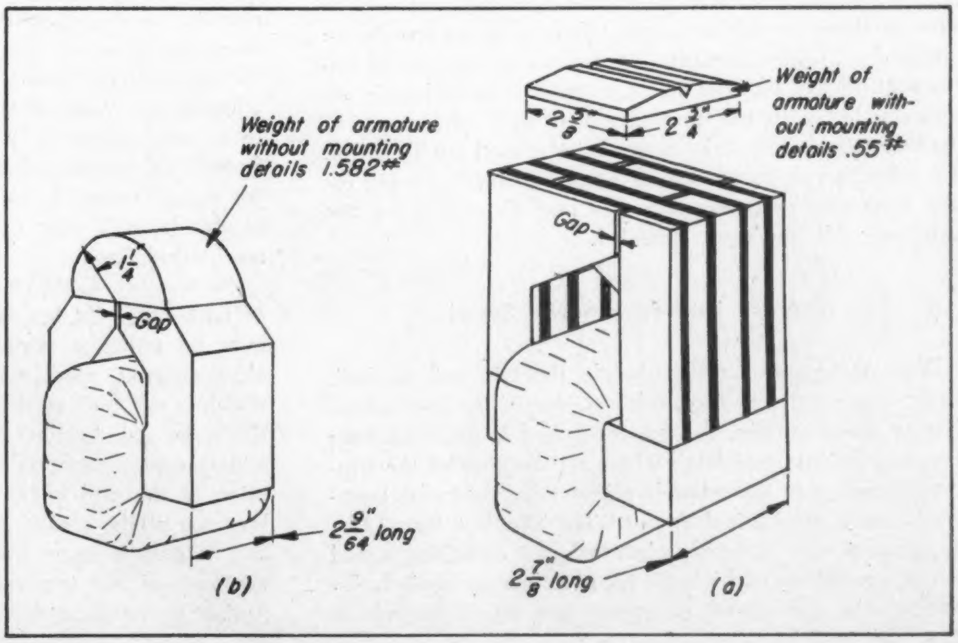


Fig. 4—Right—Use of interleaved pole surfaces, a, makes possible considerable weight reduction over a conventional magnetic latch, b, or greater speed for the same weight

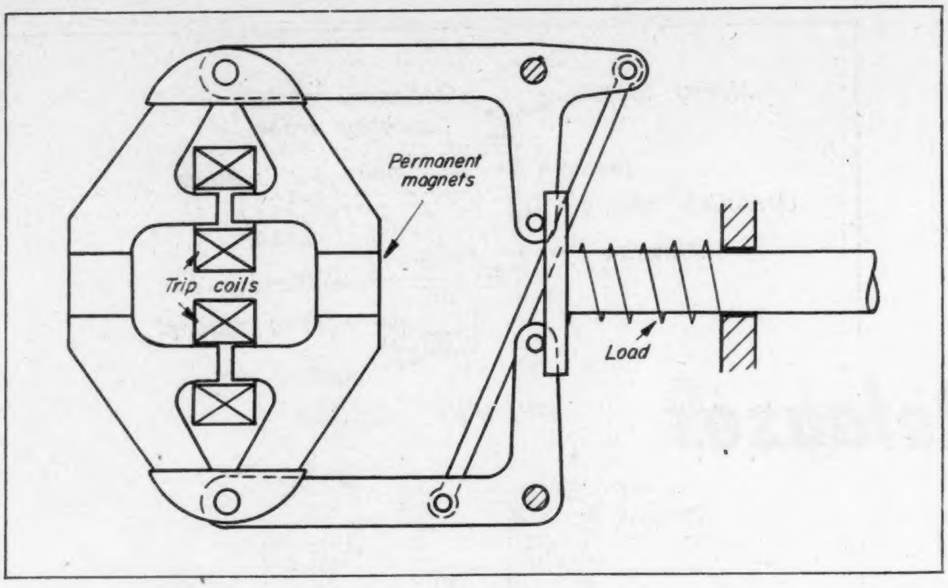


Fig. 5—Left—Releasing force of the latch in Fig. 4a can be doubled by using two armatures in series as shown

the reduced area will be twice that of the larger area. Therefore, the smaller armature will move more rapidly and will provide more force at the trip latch.

3. The rapidity of the build up of the force-causing magnetic flux depends on the buildup of the current which, in transient circuits, depends on the resistance. To obtain shorter time, the resistance must be increased. This often results in impressing a higher voltage on the coil to obtain the required amperage against an increased resistance in the shortest time.
4. The rapidity of the buildup of the current varies inversely as the inductance of the coil. Faster action may be obtained by increasing the current and decreasing the number of turns, keeping the required number of ampere turns constant. Naturally, the maximum speed is obtained when there is only one turn in the coil.
5. Circuits with the least losses are apt to give the fastest results. For example, the use of laminations instead of solid bars in the magnetic structure, the use of high-silicon steel, etc., permit faster buildup of the current.

Materials for the magnetic circuits are generally low-carbon steel. For faster results, annealing in hydrogen is of advantage. Lamination of the structure and use of special alloys are advantageous where ultimate speeds are necessary. Under corrosive conditions, it may be of advantage to use stainless steels, even at a small loss in efficiency but with the assurance that such efficiency will be maintained. The stainless steels to be used are Type 302 for nonmagnetic parts such as the coil spool, Type 410 for the stationary magnetic structure and Type 416 for the armature, all hydrogen annealed.

Magnetic Latching Improves Speed

The Magnetic Latch: While the trip coil method, using a moving armature, releases any of the mechanical latches quite rapidly, the greatest speed is obtained from the magnetic type of latch where the buildup of the tripping circuit acts immediately without having to be transferred to a mechanical device. The simplest form, *Fig. 2a*, consists of a horseshoe electromagnet exercising a pull on an armature on which the tripping load is exerted. To release, the coil circuit is opened and when the flux is

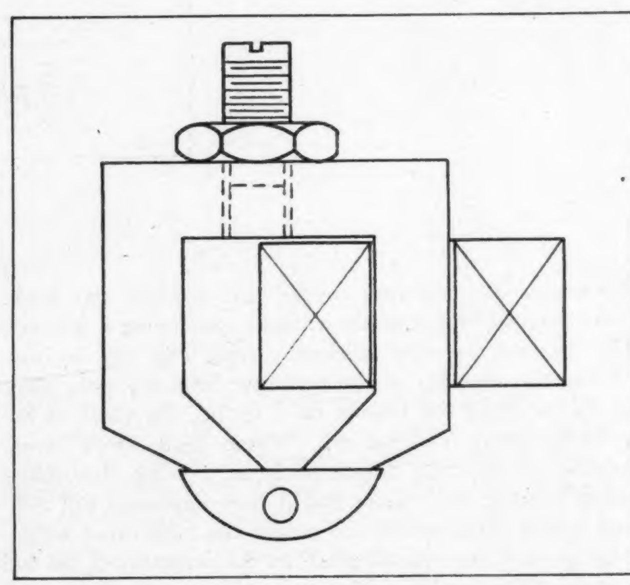


Fig. 6 — Below — A threaded plug in the iron circuit of a magnetic latch allows adjustment of the iron area to vary the holding force as desired

reduced to a sufficiently low value, the load forces the armature to move. The speed of this release depends on the same circuit factors as that of the simple trip coil. In addition, the value of the holding circuit may be reduced to a point where it is just sufficient to resist the load forces. Of course, where shock or vibration are factors, the margin cannot be too small. At best, the time obtained in this latch is only a little better than that of a good mechanical design.

To improve speed characteristics, the flux shifting type of latch, *Fig. 2b*, has been designed. The holding force may be either a permanent magnet, as shown, or an electromagnet, since tripping is obtained by a means which is not part of the holding circuit. In parallel with the main gap bridged by the armature, there is a secondary gap surrounded by a trip or bucking coil. Energization of this coil in the proper direction reduces the reluctance of the secondary gap to a point where the main flux is shifted away from the load-resisting armature to the core of the trip coil and the armature is released. Action is accelerated by the fact that the direction of

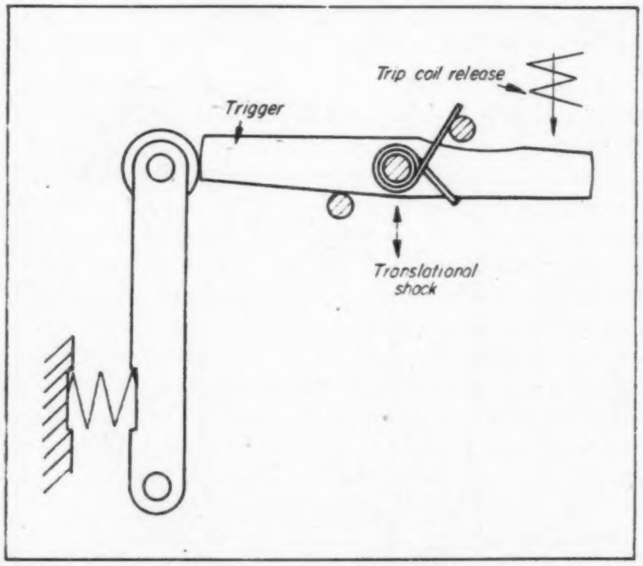
the flux in the trip coil magnetic path bucks the flux in the armature.

Application of this type of latch to a high-speed circuit breaker is shown in *Fig.* 3. To obtain rapid buildup of flux in the tripping circuit, a bucking bar, which is the equivalent of a one-turn coil, is used.

Operating speed of the magnetic latch may be further increased by the use of an interleaving magnet face as illustrated in *Fig. 4a*. Using the same area and flux density as the conventional latch, *Fig. 4b*, the width of the gap is held constant while its length is increased many times. Since the flux can pass from one pole to the other on a much wider front, the height of the armature can be reduced for the same cross-sectional area available to the flux. Therefore, the weight of the armature can be materially reduced. In the example shown, the armature in *Fig. 4a* weighs only 30 per cent of that in *Fig. 4b*.

Where still greater speeds are required, the construction shown in *Fig.* 5 is of advantage. Assuming the same area and flux density as used in the *Fig. 4a* design, it is possible to double the releasing force by using two armatures in series. Since the inertia of the armature is usually only a small part of the mass of the latched device which is to be accelerated, doubling of the accelerating force results in greater acceleration for the entire device. This design, as will be explained later, possesses greater shock resistance and therefore permits a lower margin between the holding and releasing forces.

Fig. 7—Below—By designing the latch trigger to have its center of gravity at the pivot point linear shock effects normally encountered are obviated



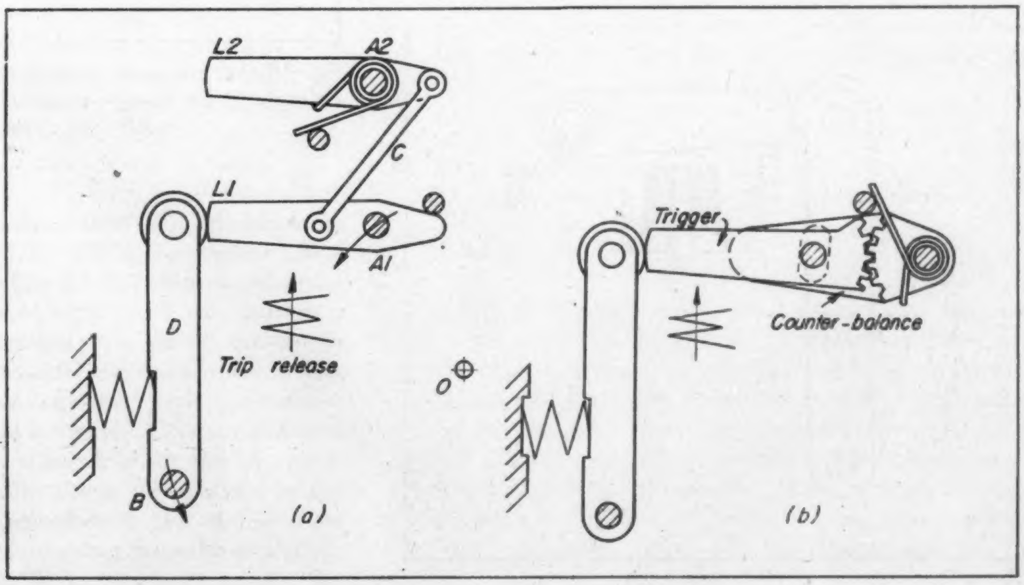
Magnetic Latch Requires Precision

The great advantage of the magnetic latch lies in its high-speed possibilities. To take full advantage of this and at the same time acquire consistent operation, it is necessary that the surfaces of the magnet and of the armature be in good contact at all times. Accurate machining and rigid construction of frames and bearings are requisites. The surfaces should be vertical to avoid accumulation of dust and dirt and enclosures should be used. The design of the mechanism must be such that the surfaces are apart only during the instant of release to improve further the chances of excluding foreign matter from the working surfaces.

Where the load to be released remains constant, as in the case of a spring, it is possible to calibrate the magnetic circuit so as to provide the most rapid operation by reducing the holding margin, or to provide operation at a given value of current in the trip coil. Several methods can be used, one of the simplest being shown in *Fig.* 6. A tapped hole in one side of the iron circuit removes an amount of material which very nearly cuts the circuit in two. A threaded iron plug can be screwed into this hole to provide any desirable area of iron in the circuit and thus to vary the holding force at the armature.

Other Release Methods: Latches may be released by other than electric devices, the most common being hydraulic and pneumatic pistons or bellows. The hydraulic method is more rapid as the speed in a closed system depends on the compressibility and travel rate of waves in the liquid. In the pneumatic system the determining factor is velocity of the gas in passages, tubes, turns,

Fig. 8—Right—Rotational accelerating forces tending to trip a latch are offset by means of rotational balancing as in a or b



valves, etc., and since the velocity, at its best, rarely goes much over the speed of sound, it is small compared with that of the electric current.

VIBRATION AND SHOCK-PROOF LATCHES: Just as the method of release is important so far as reliability and speed are concerned, it is just as necessary that a latch does not release at the improper time and under the wrong conditions. Since latch systems are usually composed of elements in which friction plays a considerable role, resonant displacement, in which the latch moves sufficiently to release, can be avoided easily by frictional damping. It can also be accomplished by a change in the natural frequency of the parts employed in the latching system.

Frictional Damping Aids Vibration Proofing

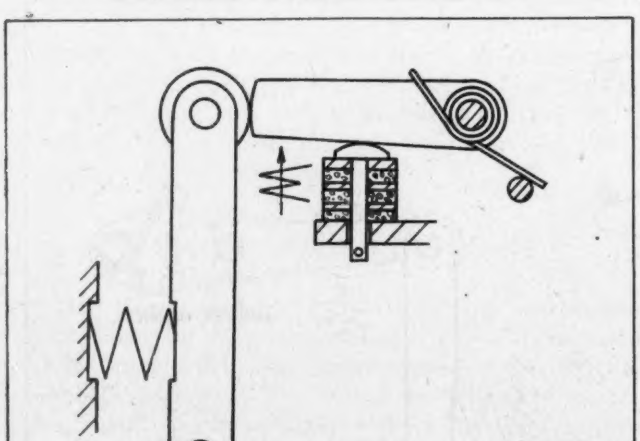
It is only necessary to have a design which offers a substantial amount of trigger motion without danger of release and such a design is found in the dead-center surface type illustrated in *Fig.* 1. The use of springs of a nonresonant gradient and the application of these springs in a way to cause frictional damping aids materially in making the latch vibration proof.

SHOCK PROOFING: To obtain a satisfactory solution of a shock problem, it is necessary first to determine the source or nature of the shock to which the latch is subjected. By shock, is meant a large and suddenly applied force acting for a short time on the body or frame providing the mounting for the latch and transmitting all or part of this force to the latch in the form of acceleration. By the process of isolation, the shock is transmitted at the pivot point of the trigger and at the trigger stop. It is obvious that the release parts are similarly exposed to shock forces and may be shockproofed by the same procedure. Before applying any method for eliminating the effects of shock, the apparatus should be so mounted, if possible, as to reduce the magnitude of the shock forces.

BALANCING METHOD: The mechanism of shock transmission through the pivot point consists of the sudden acceleration of this point and the tendency of the trigger to remain stationary in space. Where the acceleration is linear and the center of gravity of the trigger is at the pivot point, the trigger will move with the mounting and will not permit the latch to trip. Such a balanced construction is shown in *Fig.* 7.

It is more common to encounter rotational accelerating forces due to the methods of mounting or to offset forces producing moments. Under such circumstances static balancing of the trigger is insufficient and more intricate rotational balancing must be resorted to as illustrated in *Fig.* 8*a*. Assuming that the shock causes the frame to rotate counterclockwise around center O, bearing points B and $A1$ of the latch and $A2$ of the counterbalance tend to move in the same direction around O. The inertia of parts $L1$ and $L2$ tend to keep them stationary in space and therefore to give them a clockwise rotation relative to D. If this were permitted, D would be unlatched. However, between $L1$ and $L2$, there is a connecting link C so placed that the rotation of these parts must be in opposite directions. If link C is kept very light and the moments of inertia of $L1$ and $L2$ are nearly identical, it is obvious that the relative position of $L1$, $L2$ and D cannot change if their pivot points are given the same angular acceleration. Therefore, this construction is proof against a rotational type of shock. Since translational motion is a special case, this design is likewise proof against linear shock. In *Fig.* 8*b* is shown a similar device in which the link is replaced by a pair of gears. The magnetic latch illustrated in *Fig.* 5 indicates how this method can be applied to releasing parts.

Fig. 9—Below—Shock forces transmitted by way of the latch stop can be lessened to a great degree with a soft-stop which is inexpensive and effective



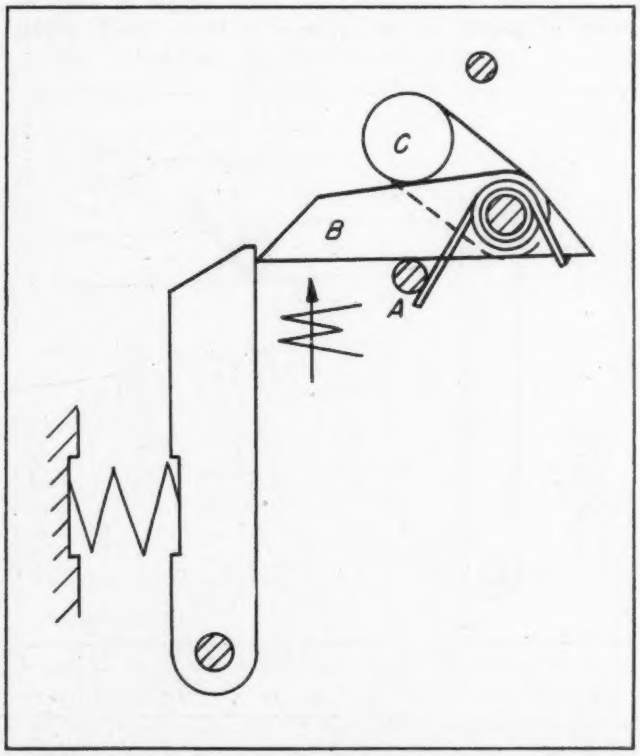


Fig. 10—Where even slight motion of a trigger will cause unlatching, an energy absorber C can be used in lieu of a soft-stop as shown in Fig. 9

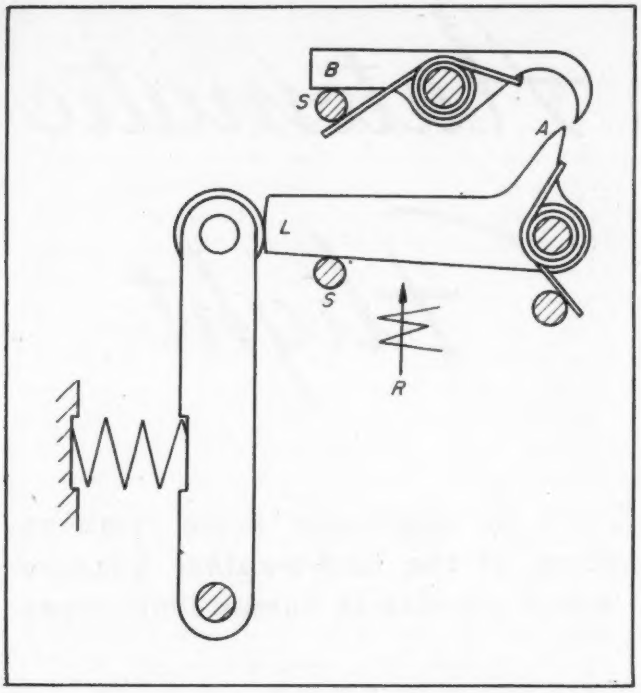


Fig. 11—When occasion demands, an interference trigger can be used to block inadvertent motion of the latch

While shock balancing may be used to eliminate effects of suddenly applied forces through the pivot point, the forces transmitted by way of the latch stop cannot be so treated. Two of the more common methods are soft-stop suspension and energy absorption. The former is illustrated in *Fig.* 9 and consists of alternate layers of soft fibrous washers and metal washers. By regulating the number and the gradient of the layers, any required softness is obtainable. The method is simple, effective and inexpensive and is particularly applicable to a latch design in which slight motion of the trigger does not unlock the mechanism.

Energy Absorber Obviates All Motion

Where even a slight motion is objectionable, the energy absorption or so called "billiard ball" scheme, *Fig.* 10, is highly effective. The rebound weight *C* bears on trigger *B* directly above the stop *A*. Any force applied by *A* to *B* is immediately transmitted to *C* which absorbs the energy in a sudden motion, leaving *B* unmoved. By the proper proportioning of masses it is possible to eliminate even microscopic motion on the part of *B*.

To overcome the effect of shock transmitted both through the pivot and by the stop, it is necessary to use one of the balancing methods of *Figs.* 7 or 8 together with one of the stop shock eliminators which are detailed in *Figs.* 9 and 10.

It should be mentioned at this point that the commonly attempted method of combating shock transmitted through the stop by increasing the tension on the latch return spring is generally ineffective. Shock forces are high and would require a spring so heavy that ordinary release means would be inadequate to actuate the latch. If such were made available, latch triggers would require stronger and heavier sections which in turn would necessitate more spring hold-down, rendering such design extremely undesirable.

Interference Method: Instead of reducing, counterbalancing or absorbing shock forces an oft-used scheme consists of supplying a means for blocking the motion of the trigger due to any reason other than the release force provided. In a typical scheme, *Fig.* 11, latch *L* is provided with an extension *A* which normally lines up with the hook of interference lever *B*. When tripped by release *R*, there is nothing to hinder the tripping of the latch. Lever *B* is usually proportioned and mounted so that it is lighter and has a higher natural frequency than that of *L*. Force exerted through stop S causes the hook of *B* to rotate more rapidly than extension *A* of *L* so that the hook blocks the motion of extension *A*. Likewise, in vibration, the out-of-phase relative motion is such as to cause interference, again blocking motion of *A*.

Interference Method Has Speed Advantage

Advantage of this type of shock design is that in normal operation, the mass moved by the release is little more than that of the trigger alone and results in greater speed. The disadvantage lies in the fact that operation is not positive, although the parts can be proportioned to give reliable results under circumstances usually encountered in normal service.

Summary: The order in which latch releases improve in respect to speed is as follows:

1. Pneumatic
2. Hydraulic
3. Solenoid
4. Simple holding coil magnetic
5. Flux shifting magnetic
6. Flux shifting magnetic with elongated gap
7. Flux shifting magnetic with elongated gap and with several breaks in series.

The methods for increasing the vibration resistance of latches are:

1. Soft suspension
2. Change of frequency
3. Damping
4. Interference devices.

Methods for improving the shock resistance of latches are:

1. Suspension
2. Static balance for linear shock
3. Angular balance for linear and rotational shock
4. Energy absorption
5. Interference

Design of latching mechanisms for any particular machine function should take into consideration these various factors relating to the release end of the device. Although the particular references in this article pertain to circuit breakers primarily, the problems incident to speed, vibration and shock resistance are basically identical and should be of value in obtaining the desired releasing characteristics in any type latching arrangement to be employed in the design of a machine mechanism.

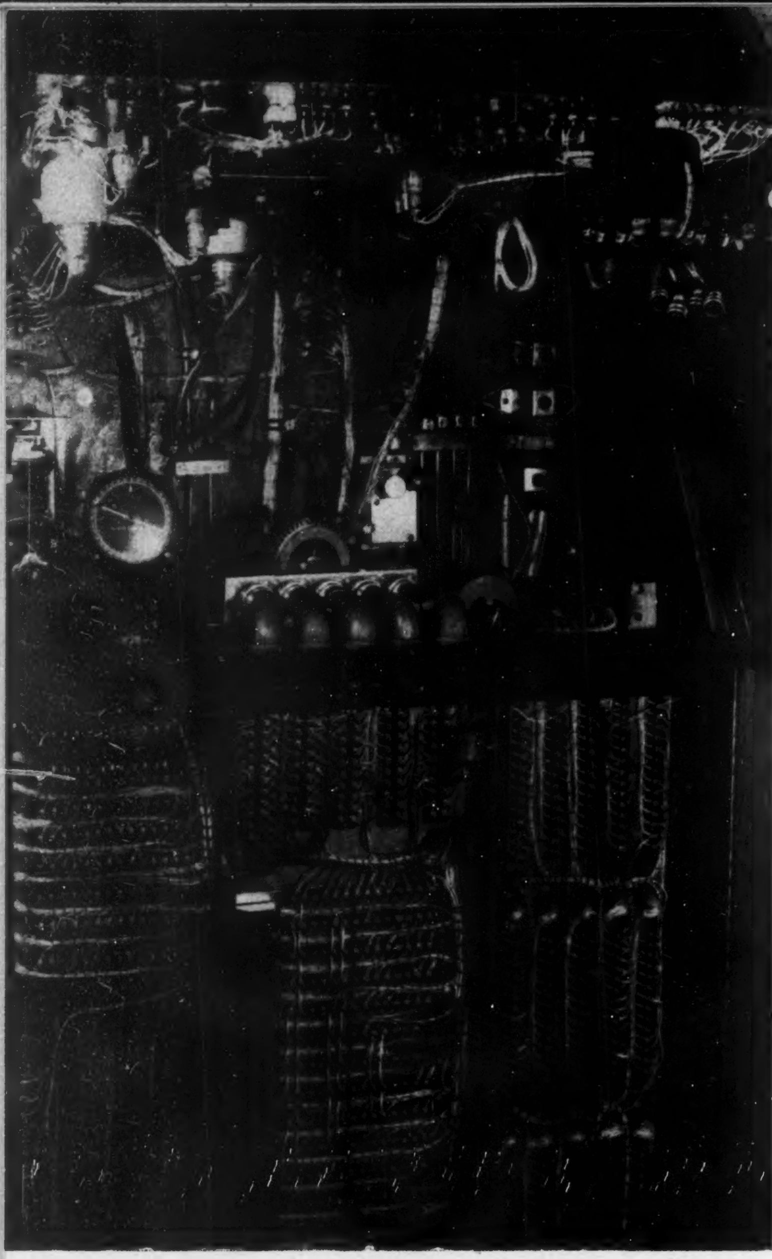


Fig. 1—Control panel of "pushbutton" C-54 plane with front panel lifted up to show some of the circuits

Automatic Flight

. . . by electronic brain removes some of the bad-weather hazards which are due to human limitations

By James L. Anast

Chief, Automatic Flight Branch
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Air Materiel Command
Wilmington, Ohio

ENTERING the cockpit of a large modern aircraft, one is amazed by the great number of instruments, dials and levers with which a pilot is confronted. It may seem incredible that they are all necessary for its operation, but these meters and dials are the eyes and ears of the aircraft and are tuned to the hundreds of functions that require monitoring for the safe flight of an air giant such as the Douglas C-54 that may weigh over 60,000 pounds.

There are no less than thirty-six instruments that indicate temperatures, manifold pressures, speeds, and fuel quantities, and fourteen levers to adjust the four 16-cylinder engines, which churn out a total of 5000 horsepower, to their optimum performance. In addition there may be as many as twenty instruments that sense flight information such as attitude and airspeed, not including from thirty to forty dials for the operation of the various navigation devices, such as the automatic radio

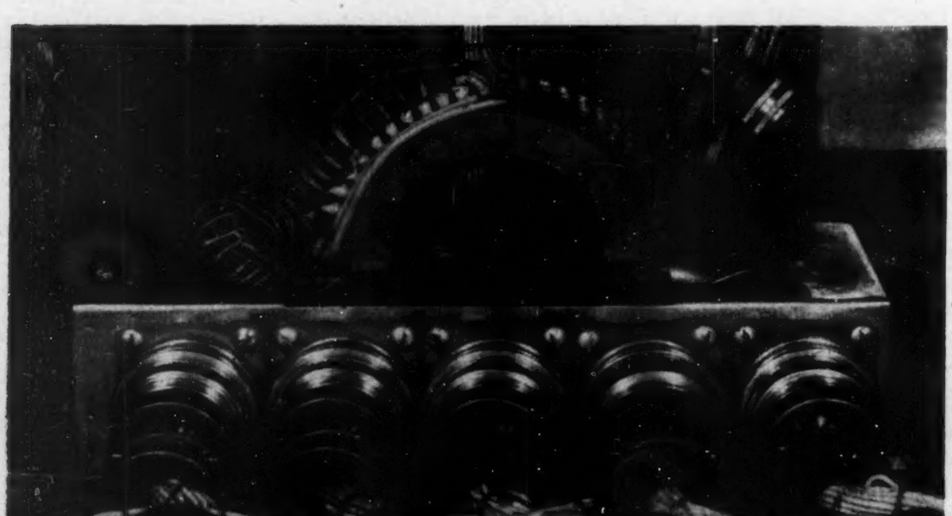


Fig. 2—Detail view inside control panel showing multigang, multiposition rotary switch forming part of the master sequence selector

compass, liaison and VHF communication sets.

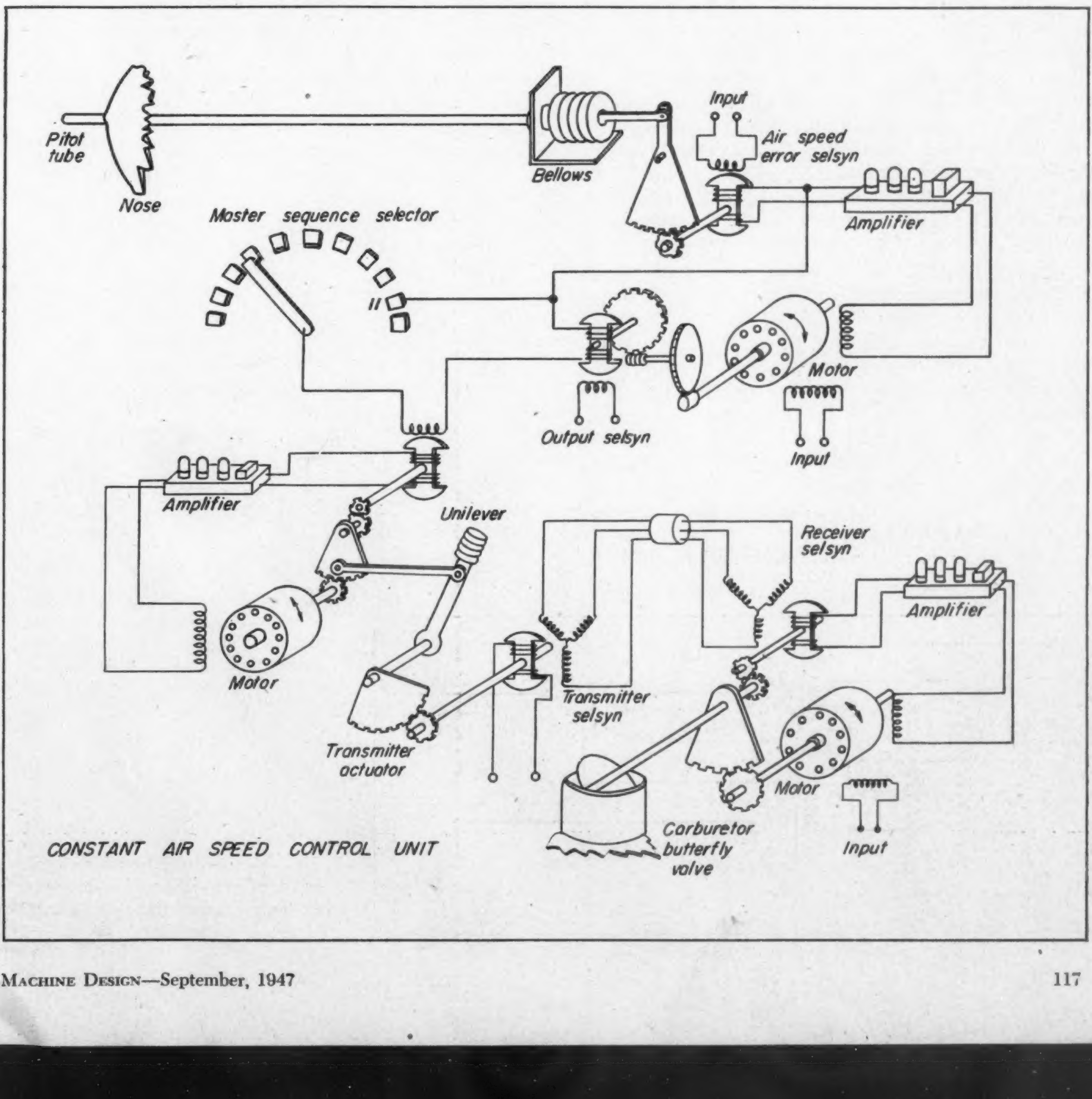
Even a child can adequately handle an automobile after a few hours instruction, but imagine driving a car on a road in three dimensions—a road that really doesn't exist—with other cars passing in all directions, not in controlled layers of traffic but free to wander in unmarked space. To guide this aircraft and keep it on the imaginary road, instead of a steering wheel, brake and accelerator, there are eight controls for speed and a delicate balanced procedure to be followed with the control column and foot pedals that usually takes a more-than-average young man over a year to learn.

To add to the problem, in bad weather the pilot has only his instruments to "sense" his speed, rate of climb, direction and position. His job is made doubly difficult when he cannot see. The operation of an aircrew in bad weather is an excellent example of human co-operation in combat with the elements. The pilot's eye never leaves the flickering needles on his instrument panel. His navigator, bent over his charts and tuned to several radio receivers, is occupied in plotting and checking the course. The crew chief is on his knees before the complicated engine control console. Even the radio operator helps by keeping in constant touch with the ground to relay important weather information.

All this activity is required to keep the aircraft straight and level and on the road. The most difficult task is yet to come—to bring this great bird, which is hurtling along at more than 200 miles an hour, down to solid earth. Making a landing in bad weather taxes the best aircrew's know-how and co-ordination. When commencing the approach, the pilot directs the crew in its detailed procedure of extending the flaps and landing gear, communicating with the tower control, adjusting the engines and turning the aircraft from its course to bring it down through fog or snow onto the landing field.

After finding the landing beam, which to the pilot is a small dial with crossed needles, the pilot begins his maneuvering to keep those needles centered. One slip at this stage of the flight can easily spell violent searing death, as has been proved by the increased number of air accidents during bad weather conditions. One old

Fig. 3—Schematic diagram of the air-speed control unit. Pitot tube in nose of ship gives signal, proportional to actual air speed, which is amplified and combined with preselected air speed to operate carburetor valves



timer in the flying game has compared the blind landing system with trying to drive a car by looking through a hole in the floorboards at the middle stripe in the road. This is an understatement, since the pilot must follow two such white lines, one for direction and the other for altitude, in addition to maneuvering eight speed controls, watching his rate of descent, attitude, and other details that require his unflagging attention.

There are so many instruments to follow that the pilot's eye scans them in a constant circle, resting momentarily on each one and passing on to the others, digesting and making mental note of the information and guiding his ship accordingly, until he lands with a jar on a runway that may be only 150 feet wide.

Controls Aircraft from Takeoff to Touchdown

Recognizing the great need for reduction of the difficulties of the pilot's tasks, the Army began experimentation at the All-Weather Flying Division of the Air Materiel Command, on the Automatic Flight Controller. Now being developed at Clinton County Army Air Field to control a large aircraft through its entire mission without human hand on the controls in the air or on the ground, the Automatic Flight Controller is not a remote radio controller, but consists of an electronic "brain" that stores information given to it before the flight begins, "reads" the flight instruments, listens to the radio signals, measures distances and air speed and carries out for the pilot and his crew all the functions necessary to conduct a point-to-point flight from one airfield to another. Its memory circuits hold the information given to it, so that in reading the flight instruments it knows which way to head, how fast to go, when to retract the gears, which stations to tune in to and follow and, finally, on which landing beam to "home". In *Fig.* 1 is shown the control panel of the Automatic Flight Controller, which recently directed a 2000-mile automatic flight from Long Beach, California to Clinton County Army Air Field, Ohio. This flight was made with no human manipulation of the aircraft controls, from takeoff to touchdown. The safety pilot, who has been working with the Controller for over a year, demonstrated his confidence in the still experimental apparatus by sleeping in a bunk provided, 5 hours out of the 8-hour flight. Virtually the only work that was going on during the flight was by the engineers who developed the Controller. They were busy collecting data on the performance of the robot.

Certain minor operations were performed manually by the crew chief, such as operation of the cowl flaps, gas mixture controls and switching of gas tanks. These functions, not being critical in proving whether automatic flight control is possible, have been given a lower priority by the engineers who tackled first the larger problems of automatic landing, navigation and designing the "brain" of the Controller.

From preliminary consideration of the data collected during early flight tests, the Controller's performance step by step seems better than when a human pilot is in the seat. The automatic engine controls do a much smoother job of adjusting the manifold pressure and synchronizing the propellers, and early results show that power consumption is lower. The air-speed control consistently holds the velocity to closer limits, and the automatic beam approach control "hunts", finds and maintains the aircraft on the beam in a manner superior to most pilots.

It is not surprising that, once the automatic flight field was investigated, a great measure of initial success was had, since an unlimited number of functions can be performed simultaneously by an automatic electronic system. The great number of controls that a human pilot must exercise are relatively simple taken one at a time, and the small safety margin that exists when flying in bad weather is due to the inability of a human pilot to perform efficiently all of the functions required to control his aircraft. The Automatic Flight Controller can add functions in parallel by the addition of more circuits, yet each function is still performed as efficiently as if it were the only control. Further, the "reading" of flight conditions, directions, etc., is done much more accurately by gyroscopes and electronic measuring circuits.

The design problem resolved itself primarily into investigation of the adaptability of equipment such as the automatic pilot and automatic radio compass to automatic flight control, and the development of electronic systems

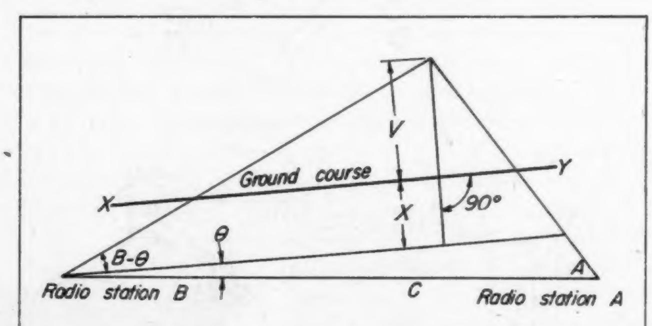


Fig. 4—Above—Diagram to illustrate the calculations which the ground position computer must perform to produce signal proportional to error V

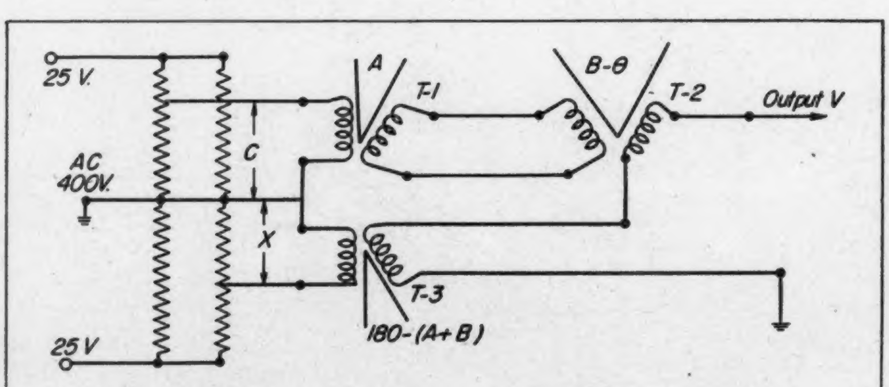
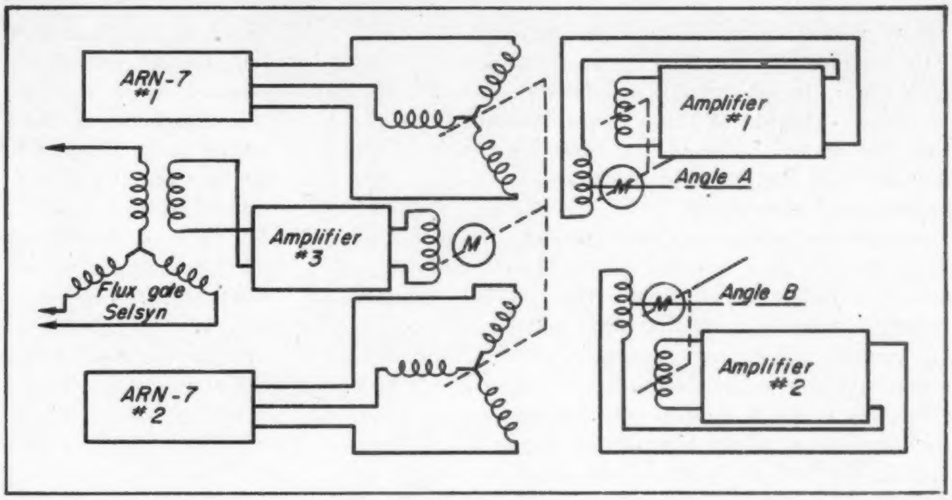


Fig. 5—Left—Simplified circuit diagram of ground position computer. Output is proportional to error V in Fig. 4

Fig. 6—Schematic diagram showing radio compass and flux-gate-compass servo system for ground position computer, Fig. 5



to reproduce the action taken by a human pilot in receiving flight information and applying it to the control that he maintains.

In general, the theory of operation of the Controller involves the utilization of information from flight instruments to furnish operation data to the control surfaces, engine controls, and auxiliary control units. During the flight, the data given to the Automatic Flight Controller prior to takeoff are combined with information from the flight instruments, and translated to electrical voltages and mechanical forces by units that cause the aircraft to take off and climb, retract the landing gears and flaps, and perform the necessary guiding functions in the correct sequence to produce completely automatic flight.

Basic equipment of the Controller is its Sperry E-4 automatic pilot. This automatic pilot consists essentially of gyroscopic units and amplifying or servo devices which transform low-power signals derived from the gyroscopes to levels which can operate motors moving the aircraft's control surfaces. The primary function of an automatic pilot is to maintain straight and level flight, but in the Controller, extraneous signals are introduced in the attitude circuits of the automatic pilot as dictated by the "memory" circuits and the flight instruments. For example, the electromagnetic energy from radio stations such as WLW is used during certain sequences of the flight to guide the aircraft automatically to the stations.

Aircraft Follows Preselected Flight Program

Schedule of the flight is determined by the Master Sequence Selector, *Fig.* 2, which is a portion of the "brain" of the Controller. This selector is essentially a group of electrical switches that operate simultaneously when their energizing circuit is actuated, and that can complete a number of electrical circuits and hold them closed until another actuation is received. The desired position is selected during the flight at the correct time and place so that reference signals from the flight instruments are fed to the automatic pilot and auxiliary operating equipment according to a predetermined schedule. This schedule progresses automatically by the use of "sensing" instruments that actuate the Master Sequence Selector at the end of each phase of the flight.

For example, in position No. 10 of the selector the aircraft "homes" on a certain localizer landing beam that guides the aircraft in direction toward the landing field. The aircraft, at this stage of the flight, flies at a constant altitude above the ground, approaching another beam that will guide the aircraft in altitude toward the landing field. The signals from this second beam, the Glide Path, are fed to the energizing circuit of the Master Sequence Selector in position No. 10 so that, at the precise moment that the aircraft arrives in the center of the Glide Path, the selector is advanced to position No. 11, where different circuits are completed. One of these is the output of the Glide Path receiver which, through suitable coupling units, controls the elevators of the aircraft to keep it on the glide path.

Automatic flight is divided into 12 operational phases:

1. Pre-takeoff (manual alignment of the aircraft with the runway)
2. Takeoff
3. Initial climb (landing gear retracted automatically when the aircraft reaches 50 ft altitude)
4. Climb to cruise altitude (flaps retracted automatically at 1000 ft altitude)

5, 6, 7, 8. Navigation sequences (aircraft flies a ground course based on directional information from ground radio stations)

9. Descent to approach altitude over a preselected radio station
10. Approach on localizer directional beam
11. Final approach and descent on localizer directional beam and glide path beam
12. Landing and taxiing.

Since it is necessary to provide different power settings of the four engines to take off, climb, cruise, descend, and land, the manifold pressure and engine speed are preselected prior to the flight and, as the Master Sequence Selector advances to its successive positions during the flight, an automatic engine control system incorporated in the Controller adjusts the power and propeller speed according to the predetermined requirements. A system has been designed that will translate reference voltages to carburetor butterfly and propeller governor position. Thus by a simple selection of voltages by one circuit of the Master Sequence Selector, all four engines are controlled during the flight. Synchronization is automatically accomplished by translating error information as determined by the tachometers into mechanical balancing forces on the governor springs to keep all four propellers

turning at the same revolutions per minute.

In position 11, the final approach sequence of automatic flight, the air speed is maintained constant to insure the correct attitude at touch down. Errors in air speed from the desired value of 120 mph are measured automatically and the manifold pressures of the four engines are regulated accordingly.

Air pressure on an open tube protruding from the front of an aircraft is a function of the actual speed of the aircraft through the air mass. This pressure is applied through a tube to a small flexible sealed bellows geared to a variable transformer, causing its rotor to shift angular position relative to the stator, *Fig.* 3. Input power at 115 volts, 400 cycles is applied continuously to the stator of this transformer, which is so designed that at one angular position the voltage induced from stator to rotor is zero. If the bellows expands due to increased pressure, caused by a greater air speed than desired, the rotor shifts, and a small voltage in phase with the stator voltages is induced in the rotor. Similarly, if the air speed decreases the rotor will shift in the other direction, and a voltage out of phase with the stator will be induced. The voltage output of the rotor, then, is proportional in phase and magnitude to the air-speed error.

How Air-Speed Error Signal Is Amplified

This voltage is applied to an electronic amplifier that operates a two-phase induction motor. The direction of rotation of this motor depends on whether the air-speed error is plus or minus. It is coupled through an 8000-to-1 gear train to the rotor of another variable transformer whose stator is excited by a 30-volt, 400-cycle voltage. This transformer—the air-speed output selsyn—produces an output which is fed back to the input of the amplifier so as to cancel out the original signal. When the motor turns the output selsyn to a position where its output is exactly equal to the output of the error selsyn, the output of the amplifier is zero and the motor stops. Thus, the air-speed output selsyn takes a position which increases in angular deviation from the null, proportional to the air-speed error. A high gear ratio is used in this system to average the small fluctuations in air pressure that are inherent in the air-speed measuring system.

Output of the air-speed output selsyn, which is proportional to the "smoothed out" error in air speed, is also fed through contacts of the Master Sequence Selector when it is in position 11, to the transmitter actuator. The transmitter actuator is a similar servo system whose output motor is connected mechanically to a lever, located on the control pedestal of the cockpit, the angular position of which becomes proportional to the air-speed error. This lever controls manifold pressure and engine speed of all four engines and can be operated manually by the safety pilot in case of emergency. During automatic flight, however, it is controlled by the transmitter actuator. This unilever is connected through a gear train to the rotor of the transmitter selsyn, which induces in its three stator windings voltages which are transmitted to the stator windings of receiver selsyns located in the engine nacelles.

Overshooting Due to Transient Errors Prevented

The windings create a magnetic field in the rotor at an angle equal to the angle of the rotor of the transmitter selsyn. The following amplifier and motor, operating in a similar manner to the error amplifier, turn the receiver selsyn rotor until it takes the same angle as the transmitter selsyn rotor. Through a gear train the motor and selsyn rotor are mechanically coupled to the butterfly valve of the carburetor, thus the change in amount of fuel-air mixture fed to the engines is proportional to the error in air speed. Additional electronic circuits are incorporated so that when transient errors in air speed appear, the manifold pressure is regulated to maintain the air speed without "overshoot" of the controls.

Referring again to *Fig.* 3, there is shown diagrammatically a portion of the Master Sequence Selector, indicating the electrical connection between the air-speed error-sensing system and the engine control in position 11. Reference voltages, preselected by a set of potentiometers, are applied to the transmitter actuator in the different positions of the Master Sequence Selector to maintain the desired power settings during the flight.

Radio Bearings Keep Aircraft on Course

During the navigation sequences of the automatic flight, the aircraft is directed on a preselected course based on the directional information from pairs of radio stations. The automatic navigation system utilizes information from two automatic radio receivers that give indications of station direction, and from the flux-gate magnetic compass which gives automatic indications of the aircraft heading with respect to true north.

Referring to *Fig.* 4, *C* equals the ground distance between the two radio stations used, *A* equals the angle of the radio station *A* from the aircraft, *B* equals the angle of the radio station *B* from the aircraft, θ equals the offset angle of the desired course, *X* equals the offset distance of the desired course as measured at radio station *B*, and *V* equals the error in ground position from the desired course. If an error voltage proportional to *V* is applied to the automatic pilot, the aircraft will fly the desired ground course. An electrical computer that receives directional information from the two radio compass receivers and the magnetic compass performs the necessary mathematical operations to solve for error voltage. It can be

(*Concluded on Page* 186)

Fig. 7—Gear train coupling from radio compass and flux-gate servo system to the computer selsyns T-1, T-2 and T-3

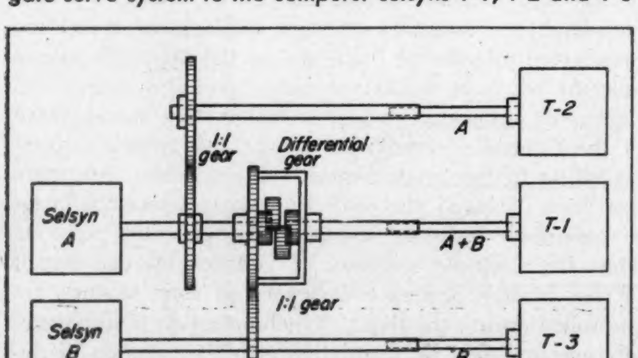


Fig. 16—High-speed radiograph, showing lead dust passing through a vacuum cleaner, made with a one-millionth second exposure

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High-Speed Photography

Part II—Radiography and Motion Pictures

IN THE previous part of this article, August 1947, various types of equipment were considered for obtaining photographs by reflected light and shadow photographs. All of these are more or less limited to photographs of the external surfaces of opaque objects. The advantages of taking extremely short-exposure shots of elements housed within a machine are obvious. For example, the engineer interested in the design of turbines would gain valuable data from photographs of a turbine wheel during actual operation. Until the recent development of the high-speed x-ray camera it was not possible to obtain photographs of such elements as turbine wheels due to the structures in which they were enclosed.

High Speed Radiography: During the period of the war, engineers and scientists of the Westinghouse Electric Corporation developed a new type of x-ray unit which is capable of making radiographic pictures during an exposure time of one-millionth of a second. One of these units was used extensively for ballistic research work during the war.

For ordinary radiographs, exposure times range from several seconds to many minutes. The length of exposure for a given voltage is determined by the intensity of the x-ray beam, which in turn is dependent upon the magnitude of the current. Normal exposures require a current of several milliamperes. In order to obtain exposure times of the order of a millionth of a second, currents amounting to thousands of amperes are required. Currents of this magnitude can not be obtained by use of the common heated-filament x-ray tube.

The Westinghouse research workers recognized the current limitations of the conventional tube, and developed a three-element tube. The third electrode was located close to the cathode and was connected to the anode

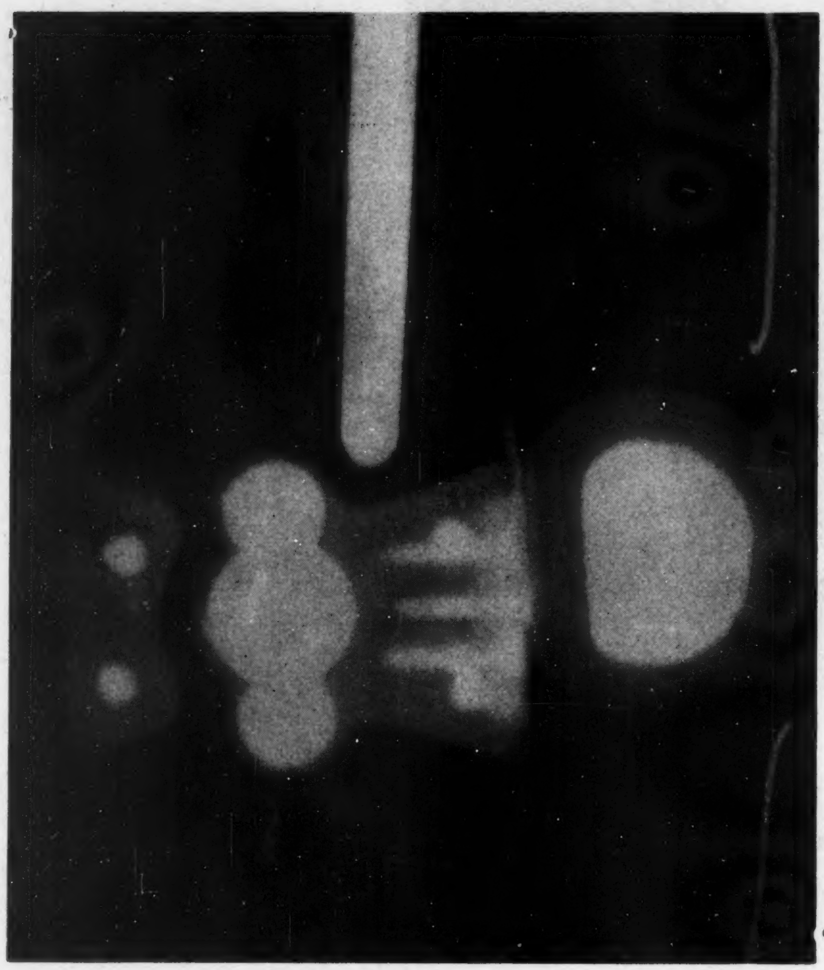


Fig. 17—One-millionth second exposure radiograph of a golf club striking a ball made with a Westinghouse high-speed x-ray tube

through a high resistance. The auxiliary electrode concentrates a high-voltage field at the cathode and starts the discharge to the anode. After starting the discharge, the electrode tends to focus the electrons on the desired area of the anode. This arrangement of tube elements makes it possible to send extremely large surge currents through the unit.

In order to establish these high current rates, a large power source is required for a very short interval of time. During the peak of operation the power consumption may be as high as 600,000 kilowatts. Duration of current flow is on the order of a few microseconds. The large transient power requirements are obtained by use of surge generators.

The main use for this equipment has been for ballistic studies. In the near future this unit should have wide application to the study of high-speed machine parts. Typical prints made from original radiographs are shown in *Figs.* 16 and 17. *Fig.* 16 shows an ultrahigh-speed photograph of a vacuum cleaner taken during operation. The lead dust particles are clearly defined as well as the mechanical elements. To obtain a photograph of this type with the ordinary high-speed camera equipment is not possible. *Fig.* 17 shows a high-speed x-ray photograph taken at the instant the club strikes a golf ball. In this photograph the internal sections of the club and ball are shown, as well as the pronounced flattening of the ball.

In the near future the designer of high-speed machine parts may utilize this type of camera to great advantage. With this equipment it is now possible for the first time to photograph in high-speed operation machine elements which are not visible or accessible for photographing by the usual high-speed cameras.

Motion Picture Photography: The problem of taking repeated pictures of a rapidly moving object has been studied since the beginning of the science of photography. The object was to take pictures of sufficiently short exposure and at sufficiently short time intervals so that details normally imperceptible to the human eye might be observed and analyzed.

It is generally believed that the first pictures of this type were made of a running horse to settle a wager as to whether, at gallop, it had all four feet off the track at any instant. A series of cameras placed along the track were operated in succession. The resulting pictures, each on a separate plate when examined, revealed that all four legs were indeed in the air at certain instants. With the development of the motion picture camera for entertainment, this new tool was used to obtain technical and scientific data. The requirements for scientific work have resulted in remarkable improvements and changes in the early type of equipment.

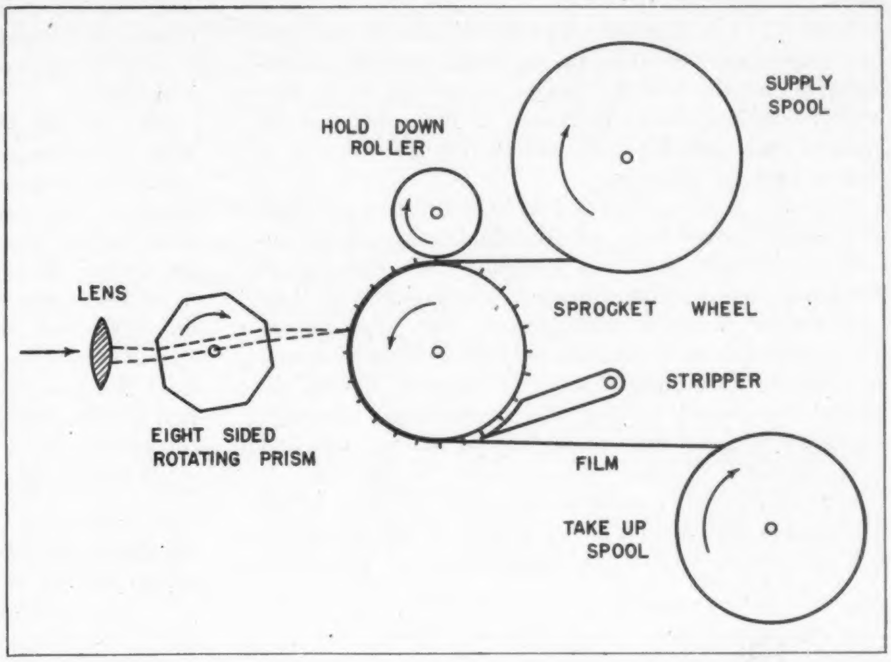
In the usual motion picture camera the film is brought to a complete stop while the exposure is made. The normal camera speed is 16 frames or pictures per second. In some cases a limiting rate of 128 frames per second has been obtained, this limit being due to the mechanical difficulties of stopping and starting the film and operating the shutter mechanism.

Mechanical Shutters Not Practical

For the extreme speeds required in high-speed motion picture work, it is not possible to stop the film, hence the film is made to move at a very high speed through the unit. The individual exposures may be obtained by an ultrahigh-speed shutter, regulated intense flashes of light, or synchronized movement of the image with the film. The use of an ultrahigh-speed mechanical shutter has many obvious drawbacks and will not be considered further in this discussion.

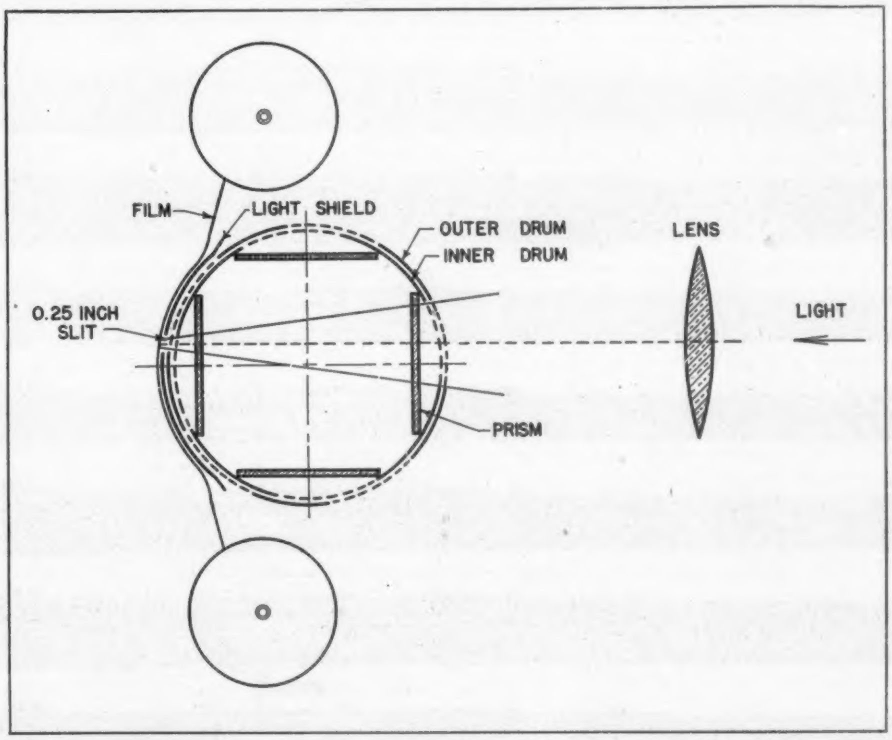
Multiple-Flash Units: One of the important types of motion picture cameras for ultrahigh speeds is commonly called the "Edgerton" type. No shutter is used in this make of camera. The unit consists of a single variable-speed motor driving a take-up spool, a sprocket, and governor. The film moves continuously from the supply spool over the sprocket drum to the power-driven take-up spool. The individual exposures are obtained by flashes from a stroboscope, the length of exposure depending entirely

Fig. 18—Right—Schematic arrangement of the Western Electric Fastax camera which employs a rotating prism to synchronize the image



upon the length of the flash. The actual positioning of the individual photographs on the continuously moving strip of film is accomplished by means of a commutator mounted on the film sprocket shaft. Although the film moves continuously, no blurring results because the travel of the film is extremely small during the time interval the flash of light exists. Due to this extremely short time interval for the duration of the flash (1/100,000-sec) powerful stroboscopic lamps are required to obtain satisfactory exposures. Cameras of this type may be obtained for taking photographs at rates up to 1500 frames per second. Usually a spark coil, energized from an external circuit, is provided in the camera assembly to furnish time marks on the film.

Fig. 19—Right—Schematic layout of the Bell Telephone Laboratories ribbon-frame camera for long, narrow photographs



ROTATING-PRISM CAMERA: Another type of high-speed motion picture camera employs a rotating prism to move the image in exact synchronism with the film. In general, the camera consists of a motor-driven take-up spool, motor-driven sprocket, rotating prism, feed spool, and lens. A schematic arrangement of the camera is shown in *Fig.* 18. As the film moves over the sprocket drum, the image is moved along the film by means of the rotating prism. A typical camera of this type, known as the Western Electric "Fastax", was developed and designed by the Bell Telephone Laboratories. Operation differs from the flash type in that a very high-intensity continuous light source is used to illuminate the object being photographed. Rotating-prism cameras are commercially available for variety of exposure rates up to approximately 8000 frames per second.

Timing intervals may be placed on the film by use of a small argon lamp which is focused on the edge of the film. The lamp, flashing on and off 120 times per second, places the time marks on the film. The film speed may easily be found by counting the time intervals for any particular section of the film.

A camera capable of taking photographs at a rate of 200,000 pictures per second has recently been developed by C. D. Miller of the National Advisory Committee for Aeronautics. Of the optical compensator type, the camera requires a continuous illumination of the object rather than intermittent light flashes. This camera does not use a long strip of film, and is capable of producing only 204 images in succession. By means of this camera it will be possible to study in detail the phenomena of detonation in engine cylinders. Other applications are for the analysis of complicated motions of machine parts

moving at very high speeds.

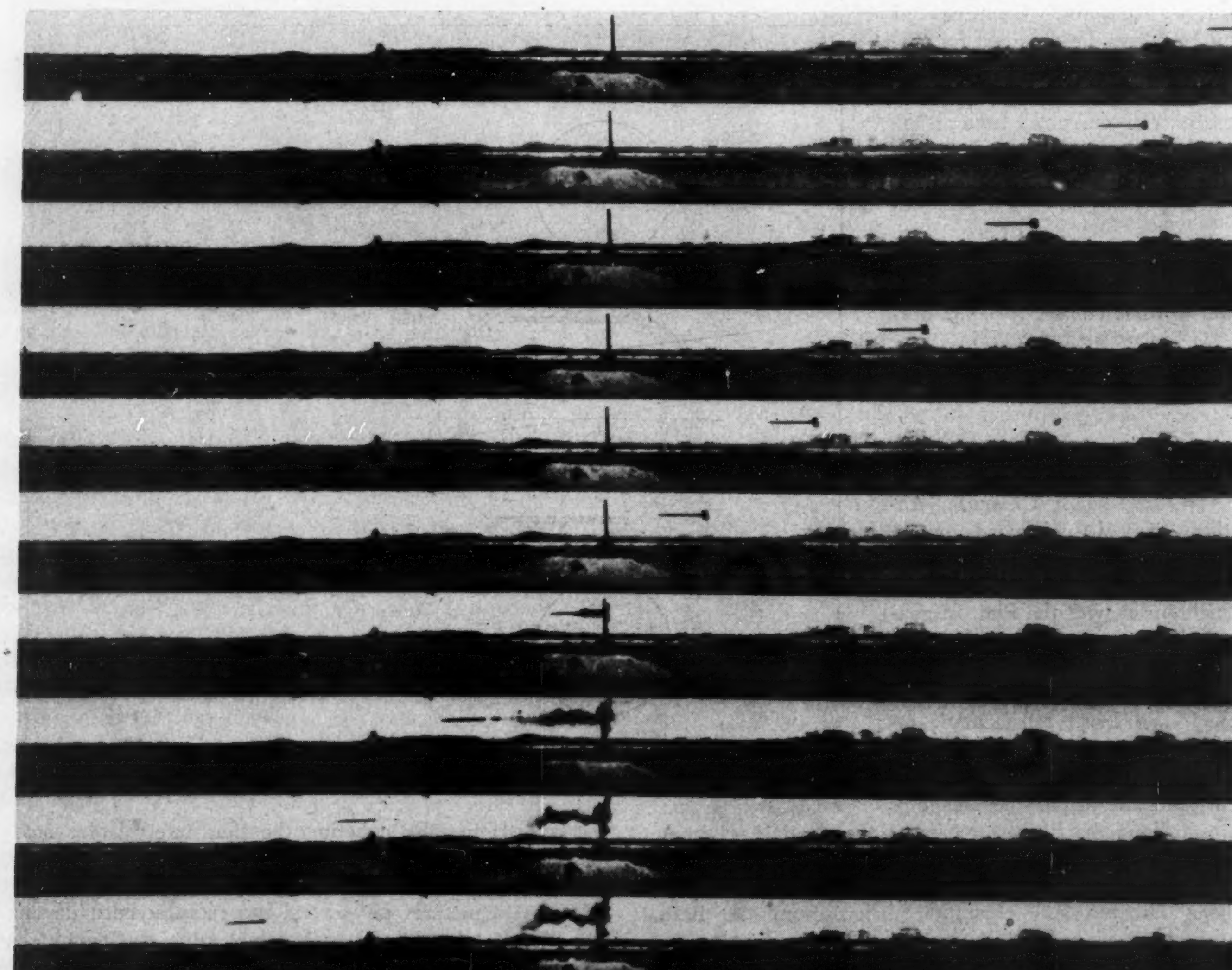
Ribbon-Frame Camera: The ribbon-frame motion picture camera was developed by the Bell Telephone Laboratories during the war to photograph rockets while they were being launched. By means of these cameras the ignition time, burning time, acceleration and velocity of rockets may be obtained.

Since the distance traveled in the direction of flight of a rocket is very large and the displacement perpendicular to the flight direction is slight, it was desirable to develop a motion picture camera which would produce very narrow but long photographs. The term ribbon-frame camera is used since the pictures produced are long and narrow resembling a series of strips of ribbon. In general the camera consists of a power-driven film-moving device, slit and light shield, special shutter, lens, and a four-element rotating prism as shown in *Fig.* 19.

Some of the ribbon cameras use a No. 122 film which is 3¼ inches wide and 35 inches long. The film is exposed as it passes over a slit which opens and closes at a speed such that 120 pictures may be taken per second. For this camera each exposure is ¼-inch high and 3¼-inches wide. A total of approximately 200 pictures may be taken on one film.

One of the unique features of this camera is the shutter mechanism. It consists of two concentric drums which are driven at slightly different speeds through a planetary gear train by a constant-speed motor. Wide slots running the length of the drum are cut in each of the drums. The inner drum has four slots and the outer drum five slots. Due to the differences in the speeds of the drums and the number of slots, the proper gap will appear 120 times per second. At the proper time light from the lens passes through the drums and slit to the film on the opposite side. The opening near the film is completely closed by the solid sections of the two drums at all other times. Due to the fact the film moves conti-

Fig. 20—Below—Series of ribbon photographs showing a rocket piercing a steel plate taken with a Bell Telephone ribbon-frame high-speed camera



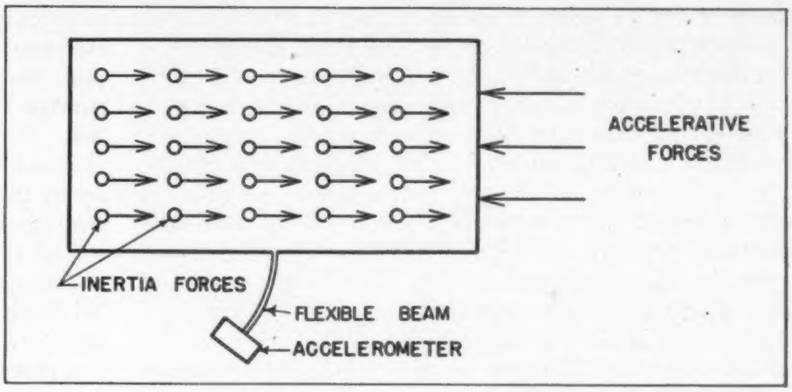


Fig. 21—Right—Schematic sketch of an accelerometer, deflections of whose beam will indicate accurately any accelerating forces transmitted to the weight attached

nuously, during an exposure the film would travel enough to blur the image. In order to prevent this blurring action four optically flat prisms are mounted in the inner drum as shown in *Fig.* 19. As the drums rotate, the prisms move the image at the same rate as the film travels, thus the image produced is free of blurring. The drums, film spools, and other related apparatus are housed in a light-tight box. An indicator is provided on the outside of the camera to indicate the amount of film which is unexposed.

A typical section of a film strip is shown in *Fig.* 20. This particular series of photographs clearly shows the movement of a rocket in flight. In the near future this type of camera will find use in the design and analysis of machine parts which move in approximately straight lines under variable velocity conditions.

Other Methods Using Photographing Recording of Data: If a machine is to operate as designed the various elements of the machine must operate as prescribed in the original design. To study and observe these motions a number of methods have been devised, many of which have been described in the preceding paragraphs.

Simplifies Study of Repetitive Cycles

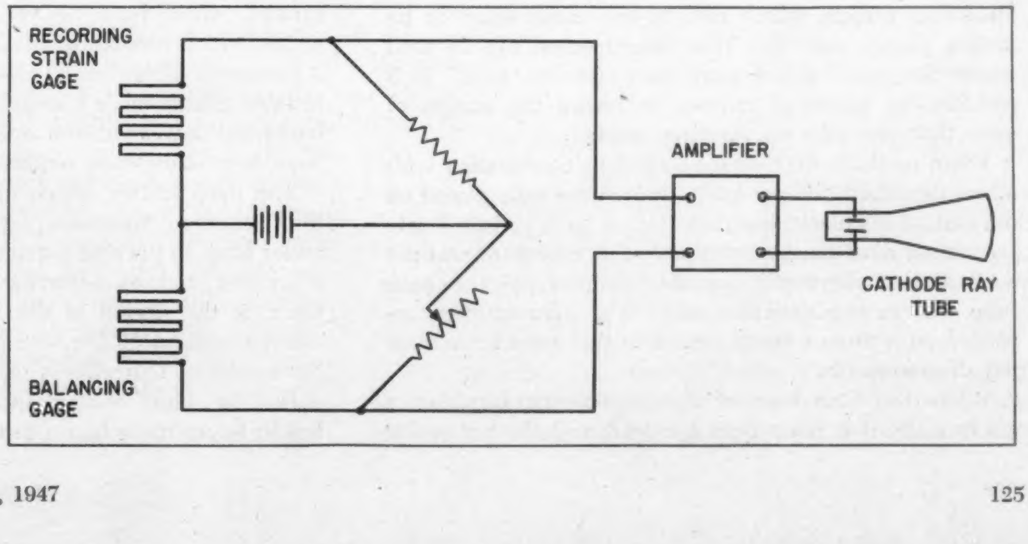
Usually the elements of a machine must perform a cycle repeatedly. In these machines it is often necessary to study the influence of wear and breakage. Since wear occurs to only an infinitesimal degree for each cycle, it is difficult to study it by investigating single cycles. Breakage and wear are usually the result of repeated applications of stress and loading, and records may be taken on selected cycles to show the existing stresses. The moving parts are usually loaded by two types of forces—externally applied forces and acceleration forces induced by the mass of the piece itself. Acceleration and force are not items which can be directly measured, but must be deduced from their effects. Force, acting on a machine element, produces stress in the element and, because of the elasticity of the material, produces small deformations or strains. It is these strains which are measured. Acceleration is likewise measured by the strains induced.

An object moving at constant linear velocity possesses no attribute which can be measured without disturbing that velocity. Hence, velocities must be obtained either by differentiating the space-time curves or by integrating the acceleration-time curves. It is also interesting to note that velocity information is of secondary importance as its magnitude does not affect functioning, or strength of materials. It is only when velocity changes (when accelerations occur) that stresses are induced.

Acceleration stresses are usually distributed unevenly throughout the part, and the measurement will be quite sensitive to the location of the gage. It is often desirable to attach an "accelerometer" for the purpose of securing data dealing with stresses and strains. This consists of a small weight on the end of a flexible beam. The weight will not be acted upon by any forces other than those of its own inertia. Consequently, deflections of the beam will measure any accelerating forces which are transmitted to the weight as shown in *Fig.* 21. The motion of the accelerometer may often be conveniently recorded by high-speed motion picture or displacement cameras.

Strain measurements may be classed in general according to the following divisions: (1) Determination of

Fig. 22—Right—Schematic layout of a resistance wire strain gage and related apparatus used primarily to record surface strains



strains which exceed a designated value, and (2) determinations which involve studying the growth, magnitude, and duration of the strain. Records of stresses which exceed a selected value may be obtained by the use of brittle lacquers or Stresscoats. These materials may be painted on a metallic surface to which they adhere readily. Their ultimate strength is very low, and may be varied and calibrated. Applied before a test, they will indicate afterward, whether the selected or calibration stress has been exceeded. This indication is given by the appearance of fine lines or cracks of the coat, which indicate the location and direction of the maximum strains. This method often is used for survey purposes, to locate positions of stress concentrations, but does not give the values of the peak strains which may have been reached during the test cycle. For example, these coatings have been used to indicate the stresses set up in firing a gun but, in order to permanently record peak strains in the order they are set up, high-speed photography could be employed. Too, the complete analyzation of points of maximum stress could be recorded by employing coats of successively higher ultimate strengths, photographing each in turn.

Recording of the transient phases of stress applications is best done by electrical means. A common pickup device is the electrical strain gage, which consists of a length of resistance wire, conveniently folded back upon itself so as to occupy a small area. This patch may be cemented to the object and will respond to changes in length of the surface to which it is attached. It should be noted that this method, as well as the brittle lacquer method, will only record those strains which appear at the surface of the part. Changes in length of the measuring wire cause changes in its resistance, and such change can be measured by its effect on the circuit in which it is placed. Because of the small strains, it is usually necessary to amplify the signals before they are introduced into an oscilloscope, where the variations appear traced by the moving electron stream. A schematic diagram is shown in *Fig.* 22.

Photography An Aid To Strain Analysis

It is well known that the strain, when translated to an electron flow, will appear as a displacement on the screen of the cathode-ray tube. If this motion is combined with a time base, the tube presents a time-strain picture which can be anlyzed by the methods of engineering mechanics. In order to make an extended analysis of the record it is necessary to photograph it. This can be done by a displacement camera which records the entire trace or by motion picture cameras. This latter method can be used where the record covers more than one time cycle. It is possible, by means of mirrors, to record the images of more than one tube on the same camera.

These methods may even be used in combination with others described. In one setup, three tubes were placed on the side of a square, and their images were reflected into a common direction by two mirrors. A time base was not used so that the motion of the luminous point in each tube was in one direction only. The motions were recorded on a drum camera similar to that used for recording displacements.

While the time base of the oscilloscope furnishes a ready scale, it is often desirable to record the happening of specific events of the strain record so that they may be correlated with other records. This is readily done by coupling other circuits, which are closed or broken by the passage of the mechanism through a characteristic position. For example, the recording of automatic gun mechanisms has long been coordinated by placing a wire across the muzzle of the barrel. When the bullet breaks this circuit, an interruption is shown on the oscillograph record.

The authors wish to express appreciation to Dr. Charles M. Slack of the Westinghouse Electric Corporation and Dr. C. N. Hickman of the Bell Telephone Laboratories for the photographs which they furnished.

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New Testing Machine More Accurate

ENTIRELY new construction principles are embodied in the University of Washington's new testing machine, designed and built by The Baldwin Locomotive Works of Philadelphia. While not the largest in use, the huge machine rated at 2,000,000 pounds incorporates several new design features which make its steel columns more rigid than has been possible heretofore, to give the machine greater accuracy and make it more versatile.

Special flex-plate construction ties the sensitive yoke to the transverse rigid beam. Three contacts are used between these two members—the capsule, which acts like a ball bearing and has no vertical stability; the initial load springs, which have no vertical stability; and the flex plates, which provide practically no vertical restraint and a maximum of horizontal rigidity. Another feature is adjustable guides, made triangular in shape, not only to keep horizontal movement to a minimum but to lock the crosshead in position when required.

The third feature which makes it possible to maintain the minimum tolerance against horizontal deflections under load, to prevent premature buckling of compression specimens and to neutralize horizontal components of force, is the flaring of the steel columns from a point about one-third of the way from the top to the base of the machine. This affords maximum rigidity or minimum deflection when testing specimens so long that their height forces the columns to function as cantilever beams.

Hydrostatic Lubrication

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Columbia University
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Part IV—Oil Cushions

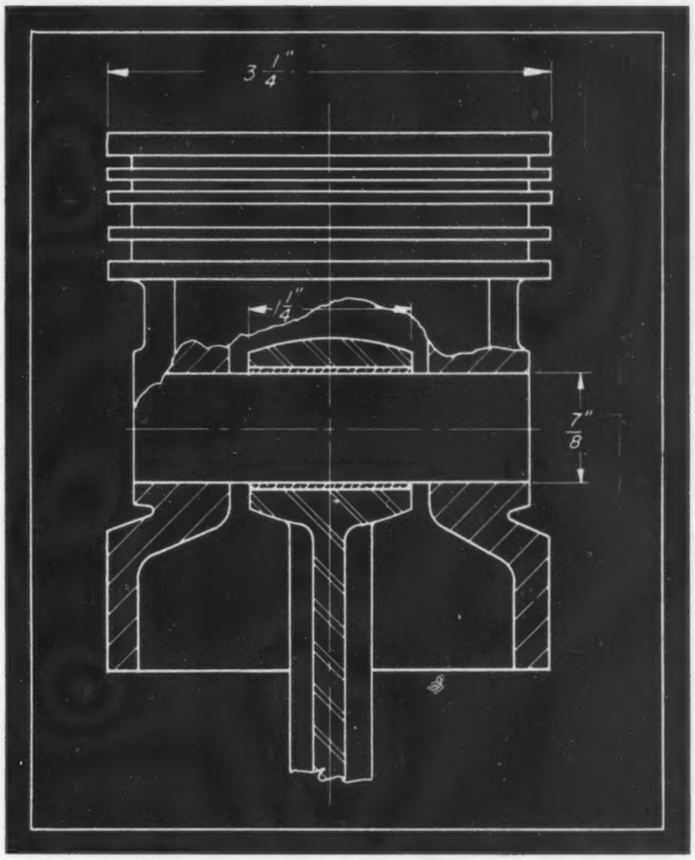
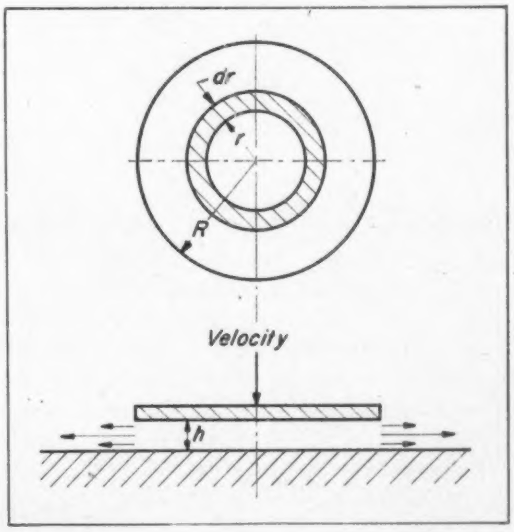


Fig. 35—Above—Typical internal combustion engine piston and piston-pin bearing in which oil cushion effect is important factor

Fig. 36—Below—Force when oil film is squeezed out accounts for ability to resist momentary loads at zero rubbing speed



MANY types of machines produce pulsating or reciprocating loads on bearings and bearing surfaces on which, because of high pressures and lack of continuous sliding or turning motion, oil-film breakdown and relatively severe wear are to be expected. Strangely enough this wear does not always appear. Crossheads, piston-pin type bearings and knuckle-joint bearings may show remarkable freedom from metal-to-metal contact, *Fig.* 35. Apparently, when conditions are favorable, an oil film is maintained between the contacting surfaces even though the relative motion of these surfaces becomes momentarily zero.

This load-carrying phenomenon arises from the fact that a viscous lubricant cannot be instantaneously squeezed out from between two surfaces that are approaching each other. It takes time for these surfaces to meet and during that interval, because of the lubricant's resistance to extrusion, a pressure is built up and the load is actually supported by the oil film. If load is applied for a short enough period it may happen that the two surfaces will not meet at all.

When the load is relieved or becomes reversed, the oil film often can recover its thickness in time for the next application, if the bearing has been designed to permit and assist this build up. Indiscriminate location of oil holes, oil grooves and reliefs may interfere with the restoration of the oil film and destroy the major part of its load-carrying capacity.

For some years dynamically loaded bearings on which the load alternates or rotates have been the subject of much interest, conjecture and research. The most important of these are the bearings in aircraft and automotive engines. It is recognized that under certain conditions these bearings will safely carry greater loads than those predicted by the classical bearing theory based on the concept of a load acting only in a single direction[1]. It is now agreed that the difference between the characteristics of unidirectionally loaded bearings and those with a rotating or reciprocating load is related to the ability of bearing surfaces to support a load when there is no relative sliding velocity.

The basic equations of hydrostatic lubrication, as developed in previous articles of this series, will serve to relate the variables and allow prediction of the action of these

[1] References are tabulated at end of article.

bearings when there is no relative sliding motion.

Consider two circular flat plates of radius R approaching each other, or a single circular plate of radius R approaching a large surface, *Fig.* 36. The clearance space between is filled with a viscous liquid which is being displaced radially outward by the relative motion of the plates. An elementary circular slot can be imagined through which the liquid is being forced. Depth of slot in direction of flow is dr, thickness is h, and width is $2\pi r$. From Equation 2 in the first article (M.D., June, 1947, Page 112) the flow of an incompressible viscous fluid through a finite slot is

$$q=\frac{\Delta P\, b\, h^3}{12\mu l}$$

where q is flow, cu in. per sec, Δp is pressure difference causing flow, psi, b is width of slot, inches, h is thickness of slot, inches, l is depth or length, inches, and μ is viscosity in reyns (lb-sec per sq in). Applied to the differential slot this becomes

$$q=-\frac{2\pi r h^3}{12\mu}\frac{dp}{dr}$$

Inasmuch as p decreases as r increases, dp/dr is negative. The volume of fluid being forced out through this differential slot is the volume being displaced by the imaginary disk of radius r as it approaches the lower flat surface. Expressed algebraically

$$q_D=\pi r^2 v$$

where v is the relative velocity of approach of the plates, inches per sec. The volume displaced is the volume flowing through the differential slot, so

$$\pi r^2 v=-\frac{2\pi r h^3}{12\mu}\frac{dp}{dr}$$

$$dp=-\frac{6\mu v r\, dr}{h^3}$$

$$p=-\frac{3\mu v r^2}{h^3}+C$$

The constant of integration, C, can be evaluated by using

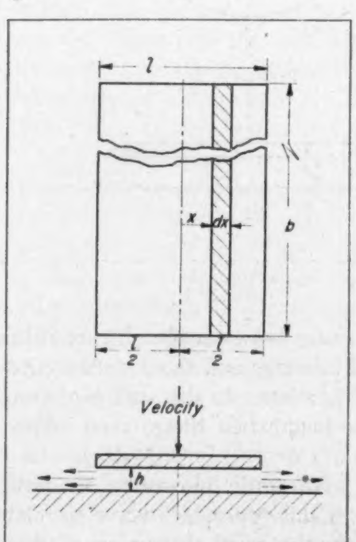


Fig. 37—Diagram used in calculating oil-cushion effect in a slipper type of bearing

the boundary condition that at $r = R$, $p = 0$, which leads to

$$C=\frac{3\mu v R^2}{h^3}$$

And the pressure at any point becomes

$$p=\frac{3\mu v}{h^3}\left[R^2-r^2\right] \quad (25)$$

This pressure variation is parabolic and on the entire surface forms a paraboloidal distribution with a maximum pressure in the center, at $r = 0$,

$$P_{max}=\frac{3\mu v R^2}{h^3}$$

For a paraboloid, the average height is one-half the maximum so the average pressure over the entire circular disk is

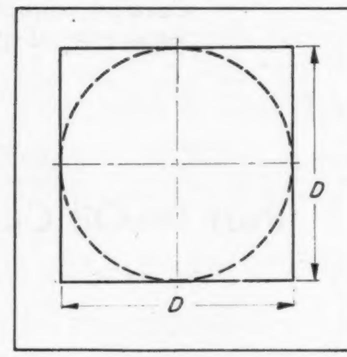


Fig 38—Restriction to escape of oil from square plate is about 4/3 that for a circular disk

$$P_{avg}=\frac{3}{2}\frac{\mu v R^2}{h^3} \quad (25a)$$

Load-carrying capacity, W, is the product of the area and this average pressure, $W = \pi R^2 \times P_{avg}$, or

$$W=\frac{3\pi\mu v R^4}{2h^3} \quad (26)$$

Equation 26 can be utilized in a number of different ways, depending upon what information is known and what is to be determined. For a constant load, W, the instantaneous velocity of approach can be computed for a given film thickness. The opposite condition can also be analyzed where there is a uniform velocity of approach. In this case, as the film thickness decreases the build-up in pressure and load-carrying capacity can be evaluated.

As an example of the first type of calculation, consider two circular plates, 8 in. in diameter, separated by a film of SAE 30 oil, 0.005-in. thick, at a temperature of 100 F. A load of 750 lb is applied to the plate.

The viscosity in English units (M. D., June, 1947, Page 112) is 152×10^{-7} reyns (lb-sec per sq in.). Then in Equation 26 for a film thickness of 0.005-in., the instantaneous velocity of approach is

$$750=\frac{3\times\pi\times152\times10^{-7}\times v\times4^4}{2\times(0.005)^3}$$

$$v=0.0051 \text{ in. per sec}$$

In the center column of Table I are listed instantaneous velocities of approach for other film thicknesses, showing the extremely rapid decrease in velocity as the oil film gets thinner. This is a cubic relationship and the logarithm of h, the film thickness, plotted against the logarithm of v, the velocity of approach, will be a straight line.

As an example of the second type of calculation, where a uniform velocity of approach is applied to the disks forming the oil cushion, consider the same two 8-in. diameter disks separated by a film of the same SAE 30 oil at the initial thickness of 0.005-in. If the plates are made to approach each other with a velocity of 0.001-inch per second, the resisting force under initial conditions will be, from Equation 26,

$$W=\frac{3\pi\times152\times10^{-7}\times0.001\times4^4}{2\times(0.005)^3}=147 \text{ lb}$$

For other film thicknesses, resisting forces are tabulated in the right-hand column of Table I. Again, a plot of the logarithm of film thickness, h, against logarithm of resisting force, W, will be a straight line.

Because of the rapid increase of the resisting force as the film thickness becomes smaller, it would be almost impossible to maintain a constant approach velocity. Another contributing factor to prevent a uniform velocity of approach is the characteristic of many fluids to become more viscous at higher pressures (M. D., June, 1947, Page 115, Equation 7). Any increase in viscosity would produce a correspondingly greater resisting force between the two plates.

Table I

Forces Between Two Disks Approaching Each Other*

Film Thickness h (inches)	Approach Velocity v (for W=750 lb) (inches per second)	Resisting Force W (for v=0.001 in. per sec.) (pounds)
0.005	0.0051	147
0.004	0.0026	287
0.003	0.0011	679
0.002	0.00033	2290
0.001	0.000041	18300
0.0009	0.000030	25200
0.0008	0.000021	35800
0.0007	0.000014	53500
0.0006	0.0000088	84900
0.0005	0.0000051	147000
0.0004	0.0000026	287000
0.0003	0.0000011	679000

* Disks 8-in. diameter, lubricant SAE 30 oil at 100F.

It is often desirable to know the time that will elapse for an oil film to be reduced to some minimum value, a value which may have been established as the thinnest permissible film for that particular bearing or bearing surface. The time required to reduce the film thickness can then be compared to the length of time the load is actually applied.

An expression for the elapsed time can be obtained from Equation 26, remembering that the velocity of approach, v, can be represented by dh/dt, the rate of change of the film thickness with respect to time:

$$W=-\frac{3\pi\mu R^4}{2h^3}\frac{dh}{dt}$$

the sign being negative because dh/dt is negative. Then

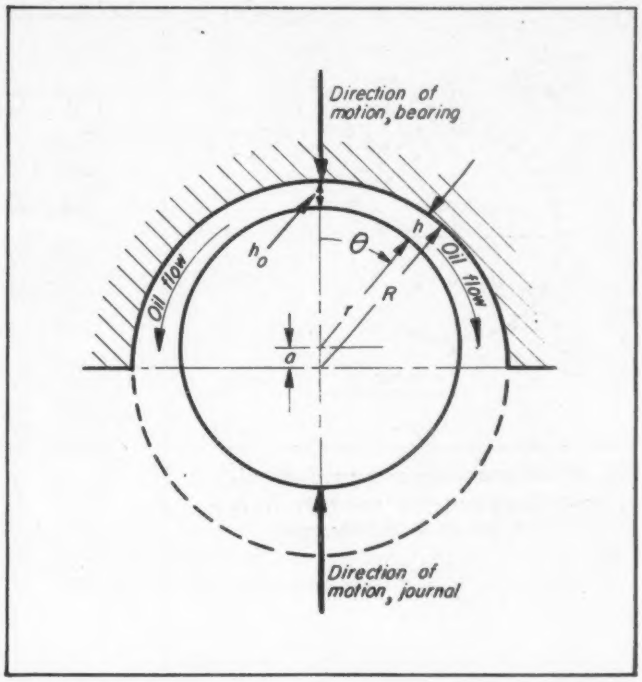


Fig. 39—Illustrating the cushioning effect of the oil film in a wrist-pin type of bearing

$$dt=-\frac{3\pi\mu R^4}{2W}\frac{dh}{h^3}$$

and t, the time in seconds required for the film thickness to be reduced from an initial value of h_1 to some final value h_2 will be

$$t=-\frac{3\pi\mu R^4}{2W}\int_{h_1}^{h_2}\frac{dh}{h^3}$$

$$t=\frac{3\pi\mu R^4}{2W}\left[\frac{1}{2h^2}\right]_{h_1}^{h_2}$$

$$t=\frac{3\pi\mu R^4}{4W}\left[\frac{1}{h_2^2}-\frac{1}{h_1^2}\right] \qquad (27)$$

In a most carefully conducted series of tests at the Kingsbury Machine works S. J. Needs has experimentally verified these "oil cushion" equations[2]. He measured the rate of approach and film thickness of two lightly loaded, optically flat disks separated by typical lubricants. The disks were ¾-in. in diameter. Among the lubricants used were castor oil, olive oil and a light mineral oil. Constant load on the plates was 0.199-lb. Using a castor oil with a viscosity of 508×10^{-7} reyns (lb-sec per sq in.) the average time (four tests) for the film thickness to reduce from 0.00016-in. to 0.00005-in. was about 1.3 hours or approximately 78 minutes.

Theoretical time for this change in film thickness is obtained by substituting in Equation 27:

$$t=\frac{3\times\pi\times508\times10^{-7}\times(0.375)^4}{4\times0.199}\left[\frac{1}{(0.00005)^2}-\frac{1}{(0.00016)^2}\right]$$

$t=4292$ sec

which is equal to 71.6 minutes, a reasonably good check.

Mr. Needs measured film thicknesses down to 0.000025-

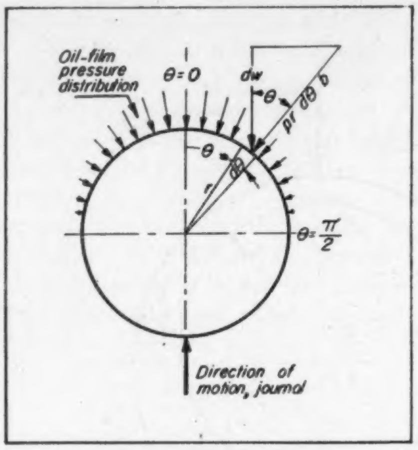


Fig. 40—Above—Diagram used in calculating load-carrying capacity from oil-film pressure distribution

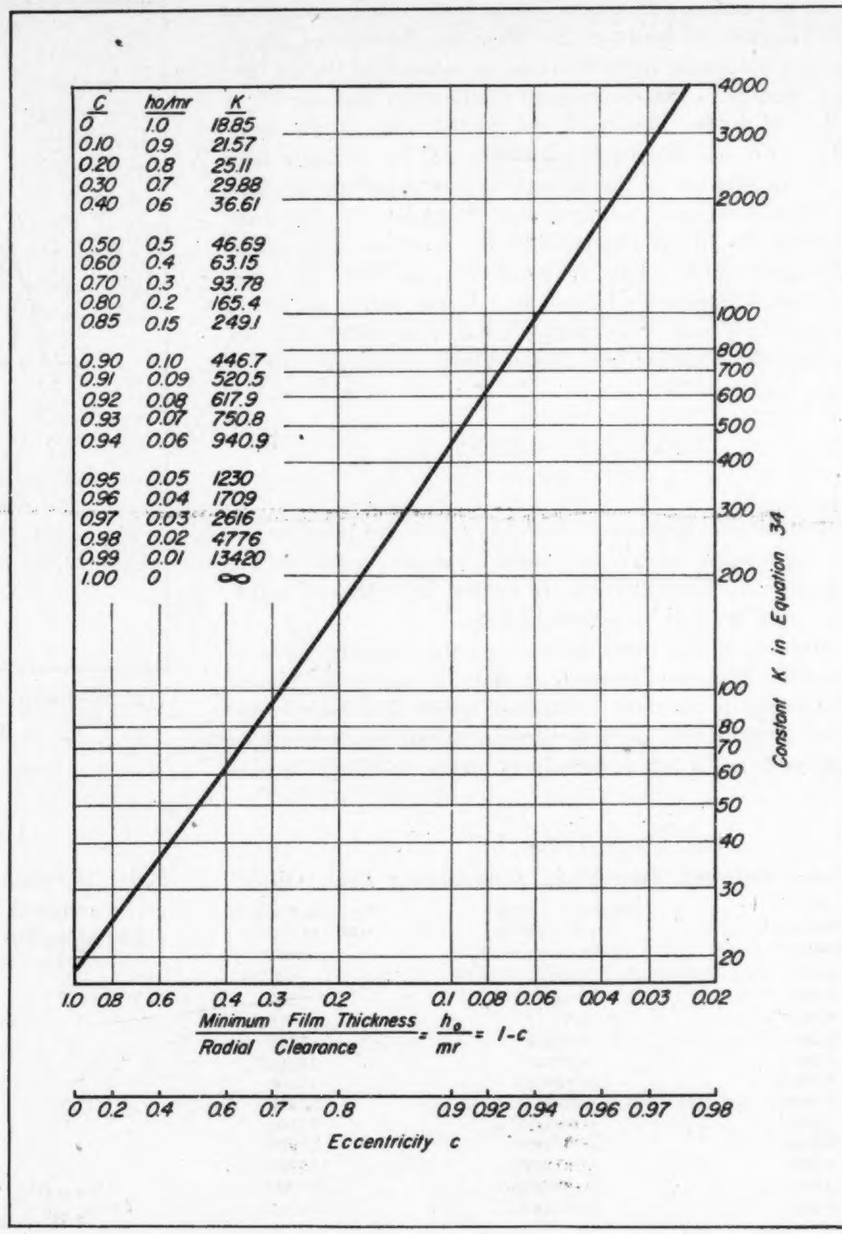


Fig. 41—Right—Values of load-carrying capacity factor, K, for various values of eccentricity

in. For values less than 0.00005-in. an increasing discrepancy appeared between measured and theoretical intervals of time. It actually took longer for the plates to approach than predicted by the use of Equation 27, indicating that the effective viscosity of the lubricant in such thin films had somehow increased. The lubricant no longer behaved in accordance with its "bulk" viscosity characteristics. No conclusive explanation can be offered except to suggest that the proximity of the metal surfaces influenced the viscosity of the fluid, causing the film to become more rigid. Contamination by minute solid particles might have the same effect in very thin films. No matter what the reason may eventually prove to be, the use of Equation 27 for very thin films—0.00005-in. thickness and less—will be on the safe side in that the actual time for approach of the plates will be somewhat greater than the theoretical.

Crosshead type mechanisms where long rectangular surfaces approach each other may be analyzed in much the same manner, *Fig.* 37. The ratio of the two dimensions b/l is assumed large so that flow will occur only in one direction, the x-direction. Again an elementary slot is pictured, through which fluid is being forced by the approach of the plates. Depth of slot in direction of flow is dx, width of slot is b, and, as before from Equation 2 the expression for the flow through such a slot becomes

$$q = -\frac{bh^3}{12\mu}\frac{dp}{dx}$$

The volume being displaced by the surfaces of width b and length x, approaching with velocity v, is

$$q_D = v\,b\,x$$

These volumes are identical, so that

$$v\,b\,x = -\frac{bh^3}{12\mu}\frac{dp}{dx}$$

Solving for p and evaluating the constant of integration for the condition that $p = 0$ when $x = l/2$, the pressure becomes

$$p=\frac{6\mu v}{h^3}\left[\frac{l^2}{4}-x^2\right] \qquad (28)$$

This is a parabolic pressure distribution with a maximum value, at $x = 0$,

$$P_{max}=\frac{3\mu v l^2}{2h^3}$$

The average height of a parabola is 2/3 of the maximum so that the average pressure on the entire plate, neglecting end leakage in the b-direction, is

$$P_{avg}=\frac{\mu v l^2}{h^3}$$

The instantaneous load-carrying capacity in terms of a constant velocity of approach is then

$$W=\frac{b\mu v l^3}{h^3} \qquad (29)$$

and, in a manner identical with that for obtaining Equation 27 from Equation 26,

$$t=\frac{b\mu l^3}{2W}\left[\frac{1}{h_2^2}-\frac{1}{h_1^2}\right] \qquad (30)$$

where t is the time in seconds for the film thickness to reduce from an initial value of h_1 to a final value h_2 with a constant force W acting on the rectangular plates.

The action of square plates approaching each other can be approximated from Equation 25*a* for a circular disk. In terms of diameter Equation 25*a* becomes

$$P_{avg}=\frac{3}{8}\left[\frac{\mu v D^2}{h^3}\right]$$

A square plate of dimensions $D \times D$, *Fig.* 38, will impose a somewhat greater restriction to the escape of oil than a circular plate because of its extra corner area. This will raise the average pressure exerted by the oil film. Estimating this effect as ½ for a square plate as compared to ⅜ for a circular plate, the average pressure for the square plate will be approximately

$$P_{avg}=\frac{1}{2}\left[\frac{\mu v D^2}{h^3}\right]$$

and the corresponding instantaneous load-carrying capacity

$$W=\frac{\mu v D^4}{2h^3} \qquad (31)$$

The time interval in seconds corresponding to Equation 27 will be, for the square plate, approximately:

$$t=\frac{\mu D^4}{4W}\left[\frac{1}{h_2^2}-\frac{1}{h_1^2}\right] \qquad (32)$$

Finally the case of a journal approaching its bearing will be considered. Typical examples are piston-pin and knuckle-joint types of bearings. A journal and bearing being forced together with some relative velocity v are represented in *Fig.* 39. Lubricant in the bearing is squeezed from the top of the clearance space down both sides as indicated by the arrows. During this extrusion process, as in the case of circular, square and rectangular flat plates, a pressure is built up in the oil film so that the load is actually supported for a time without metal-to-metal contact.

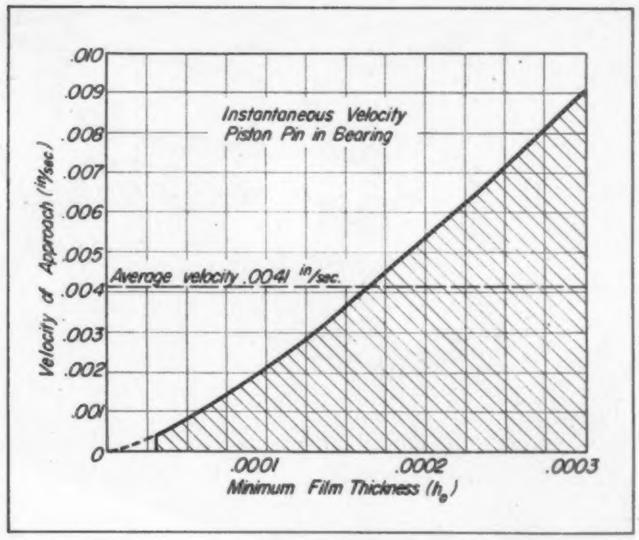


Fig. 42—Instantaneous velocity of approach of piston pin and its bearing due to load of 1037 pounds

Consider a bearing and journal of radius R and r respectively. As they approach each other the lubricant will be forced through a differential slot of length $r\,d\theta$ and width b. Assume that the bearing is long compared to its diameter so that flow along the axis of the bearing will be negligible as compared to flow down and around the sides. Again using Equation 2 for the viscous flow of an incompressible fluid through a finite slot,

$$q=\frac{\Delta P\, b\, h^3}{12\mu l}$$

As applied to this elementary slot, ΔP will be replaced by dp and l by $r d\theta$. Noticing that $dp/d\theta$ is negative, the expression for flow will be

$$q=-\frac{dp\, b\, h^3}{12\mu r\, d\theta}$$

It should be observed that h, the film thickness, is not a constant but will vary with the angular position θ and also with the relative displacement of the journal in the bearing. This relative displacement is termed the eccentricity and can be designated by c. Its value will vary from zero for perfect concentricity to a value of one for metal-to-metal contact when the journal touches the bearing. An expression for the film thickness, h, as developed in the article on Oil Lifts (M. D., July, 1947, Page 117), is

$$h=mr[1-c\cos\theta]$$

and the minimum film thickness is

$$h_o=mr[1-c]$$

or

$$\frac{h_o}{mr}=1-c$$

where m is the clearance modulus of the bearing in inches

(*Continued on Page* 188)

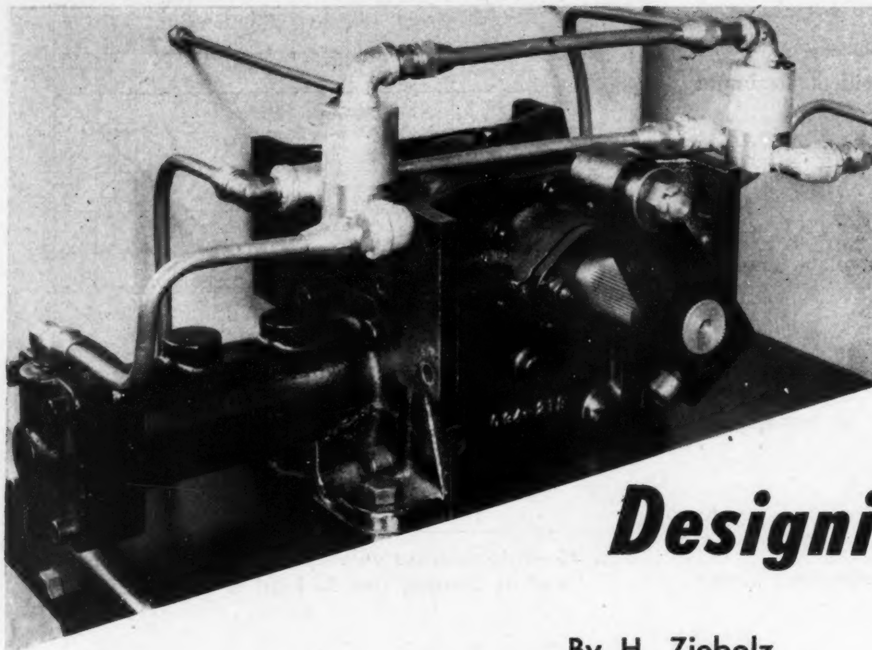


Fig. 1 — Left — Electro-hydraulic unit operated by solenoid valves

Fig. 2—Right—Basic hydraulic servo, showing possible ways to modify it for remote control purposes

Designing Pneumatic

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***UTILIZING TRANSLATORS** as a basic approach to designing pneumatic and electric servos, the author discusses these servo systems using each as a stepping stone for the design of the next. The simplified translator method has been presented in previous articles, "A New Approach to Design" in June and "Designing Hydraulic Servos" in July*

PNEUMATIC and electric servo systems are particularly suitable for accurate transmission of signals over extended distances. A power unit for such a system is illustrated in *Fig.* 1. Simple mechanical servos have a particular drawback in that there is a severe limitation upon the range over which a given input s_1 can be transmitted with a prescribed accuracy to produce a corresponding output s_2. In an attempt to arrive at a solution for the problem of transmission over greater distances, *Figs.* 3 and 4 in the article "Designing Hydraulic Servos" (M. D., July, Page 123) have been redrawn into *Fig.* 2. The wavy lines indicate possible ways of cutting the links of this diagram in order to expand the circuit over a greater area.

Line I disconnects the pilot valve *D* from the cylinder *F*. It is evident that there is no difficulty in extending these pipe lines if sufficient energy is provided to overcome pipe friction and other losses. Any effect which a lengthening of the pipe lines will have on the characteristic of ds_2/dt as a function of s_3 is not critical as long as the speed of piston *E* will become zero for $s_3 = 0$ and as long as the stability of the system is not affected.

It is more difficult to break the link between *C* and *E*. If consideration is limited to a mechanical solution of the problem, there will be only two more variables which can take the place of stroke. They are a force *F* or a pressure of a fluid *P*.

To transmit a force *F*, a mechanical connection is still needed and the solution is no better than when using stroke *s*. However, using gas or fluid pressure, a link can be obtained which may be several hundred feet in length or at least equal in length to the link between the piston *E* and the pilot valve *D*.

How this can be accomplished is shown in *Fig.* 3. The stroke s_{2a} of piston *E* is translated into a directly proportional pressure *P* by means of a "force-balanced" translator which will be described later. Thus a translator of the type (s_{2a}/P) is obtained to which is added another translator (P/s_{2b}) in series, unit *LMNO*. This produces the translator chain

$$(s_{2a}/P)+(P/s_{2b})=(s_{2a}/s_{2b})$$

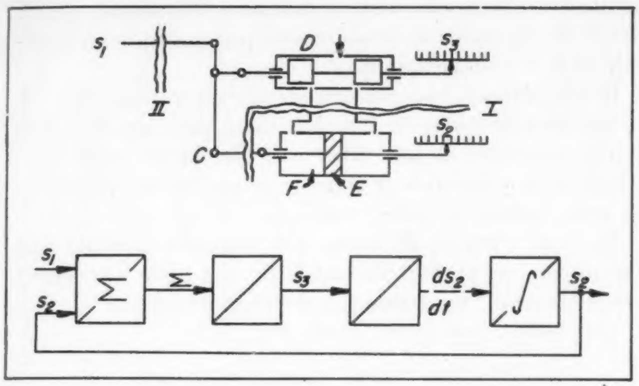
or the desired mechanical link between the motion s_{2a} of piston *E* and the motion s_{2b} of piston *N* which is identical with the motion of *C*.

It appears from the foregoing, however, that the choice of the variable *P*, a mechanical parameter, was arbitrary insofar as any other variable would have fulfilled the same purpose as long as the translator equation

$$(s_{2a}/\text{variable})+(\text{variable}/s_{2b})=(s_{2a}/s_{2b})$$

is fulfilled. How electrical links can be substituted for the mechanical ones—force, pressure and stroke—will be discussed later.

Design of the translators (s_{2a}/P) and (P/s_{2b}) calls for further explanation. In *Fig.* 3 the stroke s_{2a} is used to produce a force by means of a (stroke/force) translator



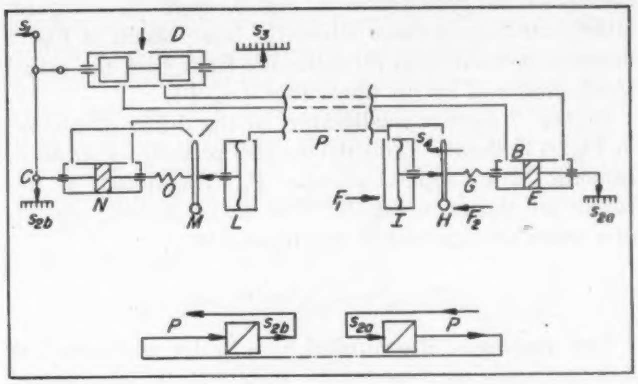
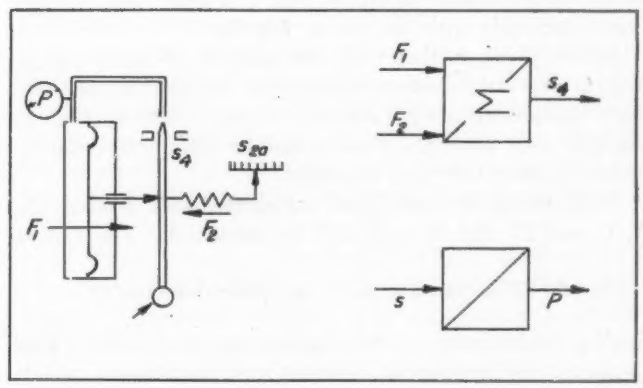


Fig. 3—Above—Modification of the basic circuit in Fig. 2, providing remote control

ic and Electric Servos

Fig. 4—Below—Translator of the (stroke/pressure) type, utilizing jet-pipe and diaphragm arrangement



(s_{2a}/F), a spring *G*. This force is used to deflect a jet-pipe relay *H* until the pressure built up on diaphragm *I* produces a counteracting force *P*, multiplied by the area of the diaphragm which balances the force of the spring.

Here, too, the elements of *Fig.* 2 are found, the only difference being that the summarizing device, the jet lever, summarizes the forces F_2 of the spring and F_1 of the diaphragm. The resulting displacement of the summarizer, s_4, produces a rate of flow of fluid dQ/dt into the diaphragm chamber, which builds up to a pressure *P* since volume and pressure are directly proportional and the diaphragm volume acts as a receiver for *Q*, integrating dQ/dt over time.

Therefore the circuit can be represented by

$$\Sigma(F_1+F_2)+(\Sigma/s_4)+\left(s_4/\frac{dQ}{dt}\right)+\left(\int\frac{dQ}{dt}\cdot dt\right)+(P/F_2)$$

$$F_1 \equiv F_2 \quad \text{feedback loop}$$

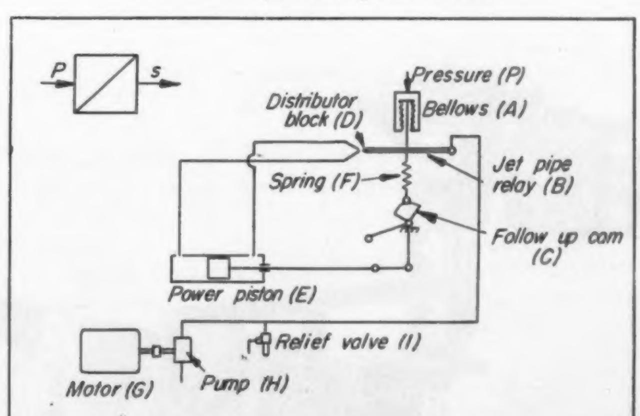
The circuit is reversed at the other end of the chain by a device which represents the translator (P/s_{2b}), see *MLNO* in *Fig.* 3. Here a force summarization is accomplished by opposing the force of the diaphragm *L* by the force of a spring *O* with a piston *N* producing a motion s_{2b}. This latter type of translator (P/s) is shown in *Figs.* 5 and 6. It is being used as a hydraulic power booster for operation of heavy dampers.

In *Fig.* 4 a loading device *A* using a pneumatic relay of the jet-pipe type produces a pressure *P*. This device corresponds to the one shown on the right-hand side of *Fig.* 3. On the receiving end the self-contained power units shown in *Figs.* 5 and 6 produce the translation from pressure back into strokes. The cam *C* of *Fig.* 5 can be so designed that it will produce any desired relationship between the applied pressure and the stroke of the piston.

In analyzing the above circuit it appears that the translator chain

$$(s_{2a}/\text{variable})+(\text{variable}/s_{2b})=(s_{2a}/s_{2b})$$

Fig. 5—Below—Translator for a (pressure/stroke) system used as a hydraulic power booster



is a simple solution for the general servo problem (s_1/s_2). Comparing it, however, with the more elaborate solution of *Fig.* 3 the following difference is found.

In the servo system, *Fig.* 5, no indication is obtained at the transmitter whether or not the receiving translator (P/s_{2b}) has responded, while in the case of *Fig.* 3 the loop is closed. While most commercial applications use

circuits of the type shown in *Fig.* 5, there are many remote-control applications where the basic circuit of *Fig.* 3 becomes preferable, as it continually feeds back the actual result produced by the transmitter (s_{2a}/P).

In *Fig.* 7 another modification of the device illustrated in *Fig.* 5 is shown. This device also produces a stroke in response to an applied pressure *P*. The details of this circuit are shown in *Fig.* 8. The device actually consists of a series arrangement of two translators

$$(P_1/s_1)+(s_1/s_2)=(P_1/s_2)$$

The position s_1 is controlled by a "valve positioner", as it is commonly used for precise adjustment of air-operated control valves. This is accomplished by applying the pressure P_1 to a force-summarizing lever which establishes a balance between the compression of a spring and the force of the bellows. The relay *K* varies the pressure P_2 on the top of the diaphragm until the diaphragm produces a stroke, which, translated into the force of the spring *R*, establishes the balance of the pneumatic relay *K*.

The hydraulic circuit which is used to obtain the translation (s_1/s_2) is identical with those previously discussed and therefore does not call for further explanation. In its behavior the device shown in *Fig.* 7 is equivalent to and interchangeable with the one in *Fig.* 6.

Before going further with the analysis of servo design and, in particular, before starting the introduction of electrical parameters into translator chains, it will be best to analyze once more the basic translator circuit in order to arrive at more universal concepts.

Designating the individual translators with symbols *A*, *B*, *C* and *D*, *Fig.* 9, each will be discussed. The first is

$$(A)=\text{The "summarizer" or "error detector"}(\Sigma)$$

Such a device compares two signals with each other. This implies in its broadest sense that it must be a device which establishes differences (summarization problem) of properties of such signals. The device is called a "summarizing device" and it should be remembered that, in order to summarize, it is necessary to translate the signals which are to be summarized into common parameters which permit such a summarization.

If, for instance, two pressure signals are to be compared, it becomes necessary to translate these pressures first into forces or strokes or into other variables of the same kind which lend themselves to summarization, as two pressures, as such, cannot be summarized.

In these symbolic diagrams it is therefore assumed that the upper box of *Fig.* 10 stands for the three (or more) boxes necessary to accomplish the summarization.

The second link in the chain, *Fig.* 9, is

$$(B)=\text{The "error translator"}(\Sigma/x)$$

This was represented by (Σ/s_3) in the previous mechanical solution and is a device which translates the sum of

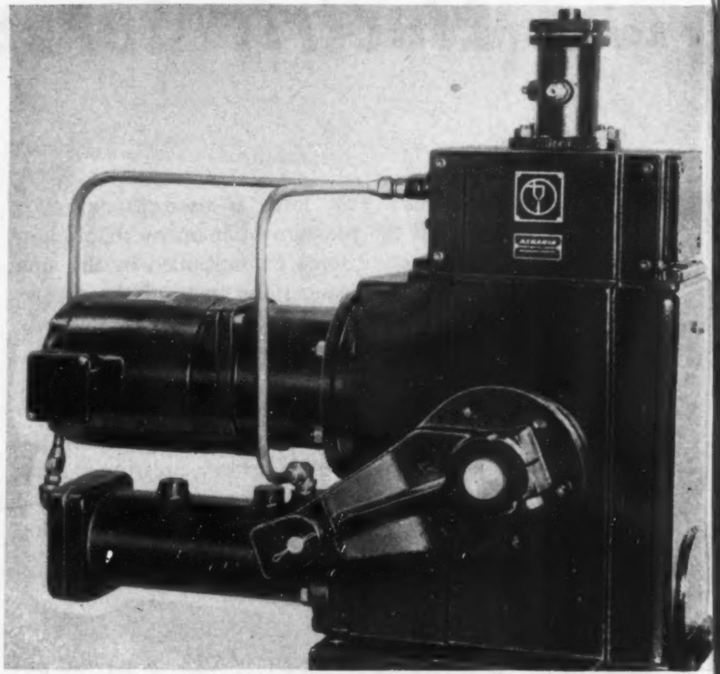


Fig. 6—Above—Self-contained hydraulic power unit shown schematically in Fig. 5

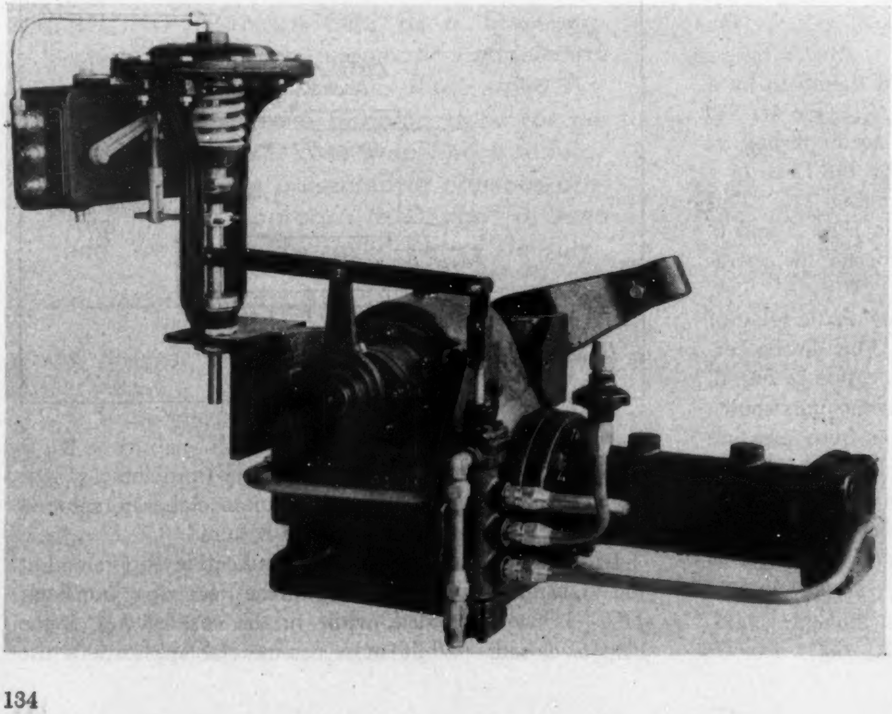


Fig. 7 — Left—Pneumatic-hydraulic (pressure/stroke) translator

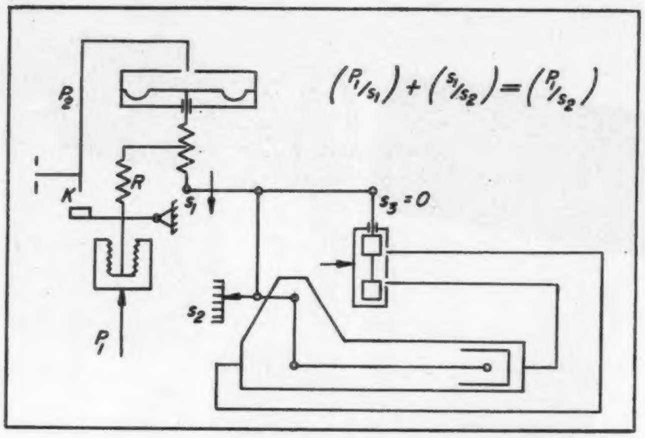


Fig. 8—Above—Schematic diagram of translator of Fig. 7

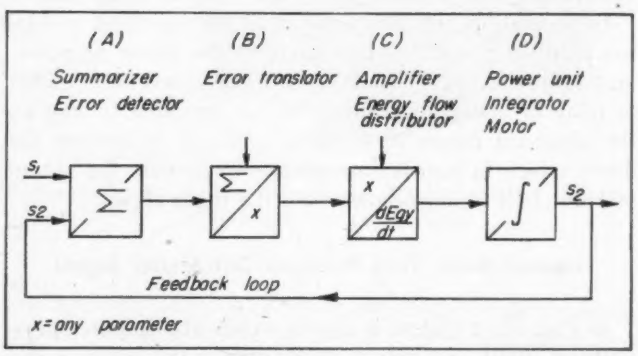


Fig. 9—Above—Typical servomotor circuit showing basic elements used in a system

Fig. 10—Below—Summarizer of the servo circuit, x being a common parameter

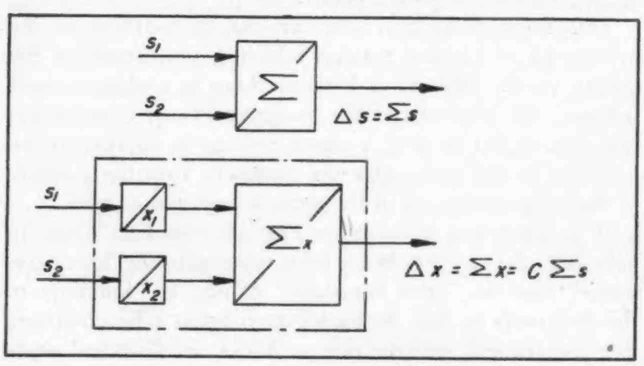
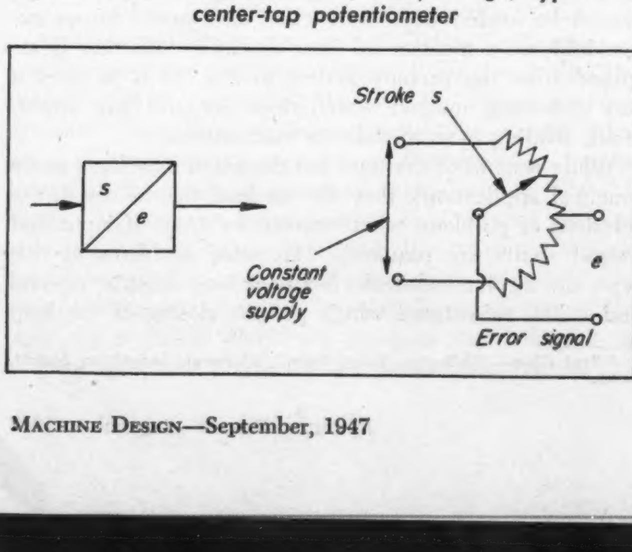


Fig. 11—Below—Translator of (stroke/voltage) type is a center-tap potentiometer



the signals, i.e., the resulting "error signal", into a suitable parameter x for transmission to the next translator (C). It has been shown that the three parameters—force F, stroke s and pressure P—can be used conveniently for this purpose. In the following discussions, electrical or other physical parameters will be used for the same purpose and the symbol x will be chosen to represent any suitable parameter.

The third link in *Fig.* 9 is

(C) = The "energy flow distributor", or the "relay" or "amplifier" $\left(x \Big/ \frac{d \text{ Energy}}{dt} \right)$

In mechanical servos this translator was written

$$(C) = \left(s_3 \Big/ \frac{ds_2}{dt} \right)$$

This was a special solution suitable for mechanical and fluid type amplifying devices. A closer analysis of the translators which have been discussed shows, however, that the broader concept of the translator (C) is one which covers the fact that this type of translator controls the energy distribution to a power mechanism in response to the translated error signal.

In the case of hydraulic circuits, this means that this translator is a fluid relay which controls the rate of flow of the pressure fluid and its direction as a function of its displacement. Obviously enough, this energy does not necessarily have to be fluid power, but can also be any other form of energy, i.e., heat, radiation, electric power, etc.

Therefore it may be concluded that the translator (C), often termed an "amplifier" or "relay", is basically a translator which controls the rate of energy supply to another device in its magnitude and direction proportionally to an "error signal" input. This may be written as

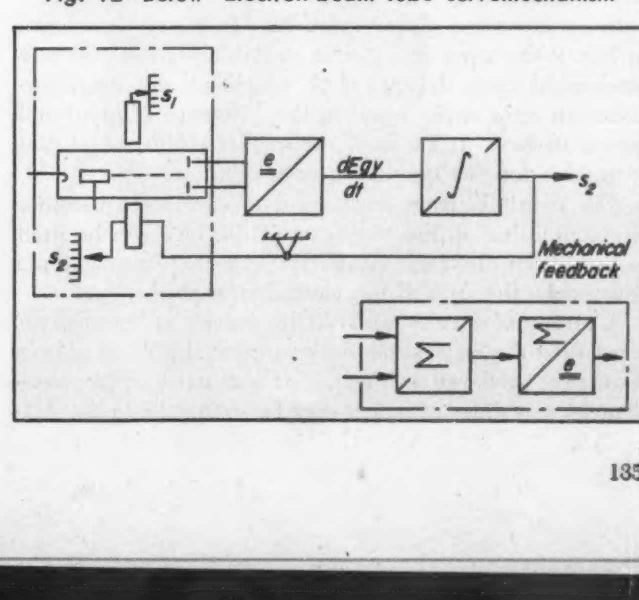
$$\left(\text{signal} \Big/ \frac{d \text{ Energy}}{dt} \right) \text{translator}$$

The fourth link, *Fig.* 9 is

(D) = The integrator device, the "power unit" or the "motor" $(\int)$

This last link in the chain is the translator which integrates the energy supply rates and produces a signal which is

Fig. 12—Below—Electron-beam tube servomechanism



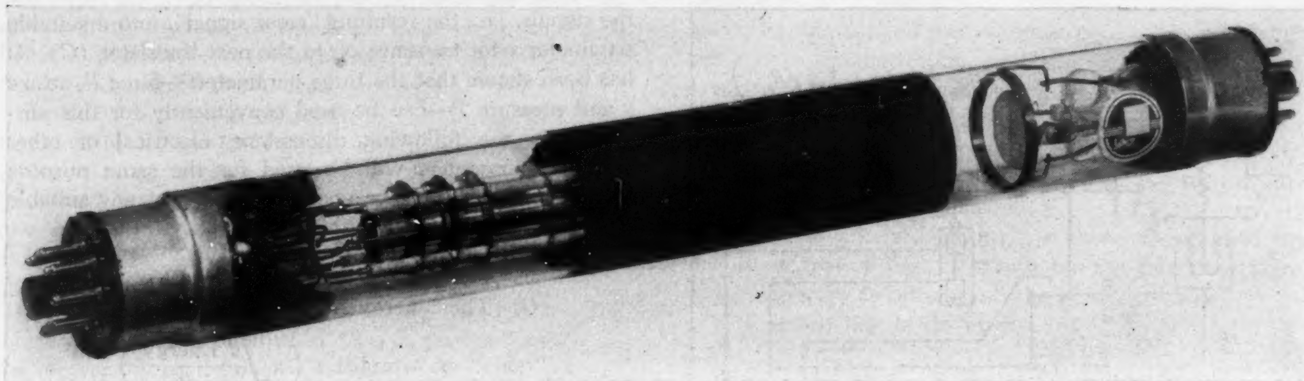
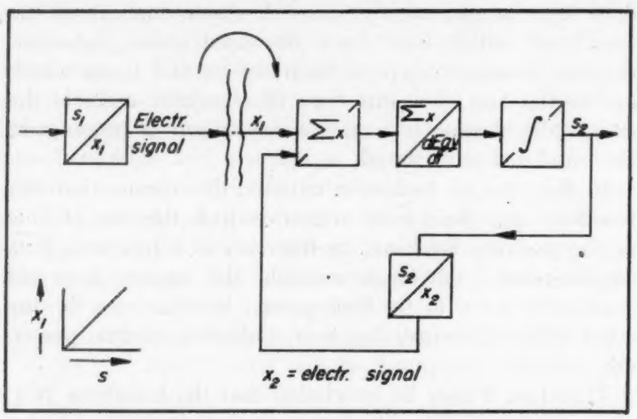


Fig. 13—Above—Electron-beam tube. Position of magnet deflects beam, producing a signal voltage

Fig. 14—Below—Basic diagram of an electric remote-control servo system



proportional to the integral of the energy supply rate of the translator (C) over time. In its simplest hydraulic form it is a cylinder; in the electrical solution, a motor.

With these very general concepts, the modification of previous servos will be approached to take care of one of the most common additional requirements—the use of electrical power for transmission of signals as well as for applying the desired power.

Basically, nothing new is added to the previous systems by using electrical connections. Electricity is simply selected as the auxiliary medium to be interposed between input and output locations.

The first two systems which will be discussed are merely stepping stones on the way from mechanical to electrical systems. While they utilize electricity as an auxiliary medium, they still require a mechanical connection between input and output locations. In the system shown in *Fig.* 9 the input and output strokes are connected to a mechanical error detector (A) which, at any time, furnishes an error stroke equal to the difference of input and output strokes. It has been shown that a differential gear is suitable for this type of an error detector.

The transition from mechanical to electrical quantities is accomplished in the translator (B), which can be used to furnish an electrical signal corresponding in magnitude and sign to the applied mechanical error stroke.

A variety of devices are available for use as "translators" translating the error stroke into an error signal. A simple translator, as shown in *Fig.* 11, is a center-tapped potentiometer the slider of which may be connected to the output shaft of the preceding differential-gear error detector. The supply voltage for the potentiometer can be ac or dc according to the design of the following amplifier circuit.

In general, the electrical output of the translator will be too small in power level to energize the motor or power unit (D) directly. Therefore, in many cases, an amplifier or relay or energy distributor (C) is provided to step up the electrical power to a value sufficient to operate the motor which in turn is dimensioned to position the output or load shaft in accordance with the input signal.

Electron-Beam Tube Produces Differential Signal

In *Fig.* 12, a system is shown which also requires proximity of input and output shafts due to the use of a mechanical feedback. The input stroke causes a small permanent magnet to travel near a beam of electrons inside an electron-beam deflection tube*, *Fig.* 13. According to the position of the magnet the beam will be deflected from its neutral position and thereby cause a signal voltage to appear across the target plates.

This beam deflection, however, can be nullified by the movement of another magnet which is positioned by the output shaft. Hence, as long as there is a disagreement between the positions of the two magnets, or between input and output strokes, a signal voltage is applied to the amplifier which will cause the motor to vary the position of the output shaft until the error is reduced to zero.

It is interesting to compare *Fig.* 12 with *Fig.* 9 and to note that the electron-beam tube represents the "error detector" plus the "error translator" of *Fig.* 9. Similarly to the two units in *Fig.* 9, the electron-beam tube compares two mechanical strokes and produces an electrical error signal as long as the strokes are unequal.

The system of *Fig.* 12 finds its place in applications where the primary element, producing the input stroke, cannot be loaded with the friction and inertia forces unavoidable in a mechanical error detector. All that is required from the primary system in *Fig.* 12 is to carry a tiny deflecting magnet which does not add any appreciable loading even to delicate mechanisms.

While systems of the type just discussed may have many practical applications, they do not lend themselves to the solutions of problems where remote locations of input and output shafts are required. To solve problems of this type, the mechanical-stroke feedback loop must be opened and a link substituted which permits closing of the loop

* Paul Glass—"Deflection Beam Tube", *Electronic Industries*, August, 1944.

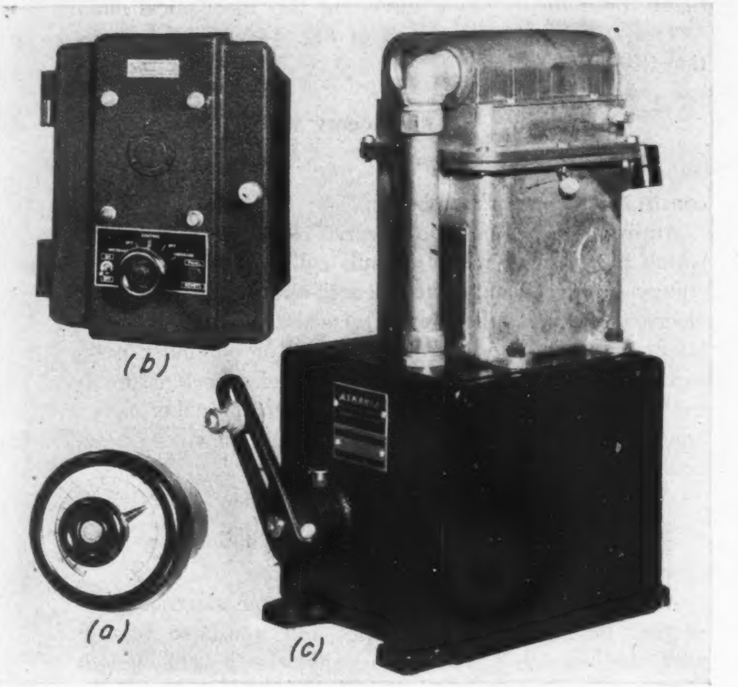


Fig. 15—Servo system comprising (a) transmitter, (b) amplifier and (c) power unit

over greater distances. It is evident that the stroke-signal translators, already used in the input portion of these systems, will be just as useful in providing a nonmechanical feedback link.

Basic diagram of a remote transmission system is shown in *Fig.* 14. Here, both the input and output strokes are translated into electrical signals in translators (s_1/x_1) and (s_2/x_2). Both translators report the positions of their respective inputs to an error device (Σx) which produces an error signal, expressing in electrical terms any mechanical unbalance between input and output strokes.

A commonly found reporting system uses, as translators (s/x), two potentiometers connected in a Wheatstone bridge circuit. The bridge performs at the same time the function of an error device so that its output voltage can be fed direct into the amplifier. A system of this type is shown in *Fig.* 15. The transmitter is the translator (s_1/x_1) of *Fig.* 14; the amplifier contains the translator

$$\left(\Sigma x \Big/ \frac{d\ \text{Energy}}{dt}\right)$$

while the receiver combines the motor ($\int$) and its translator (s_2/x_2). The summarizer is the circuit in which (s_1/x_1) and (s_2/x_2) are part of a Wheatstone bridge.

Another well-known reporting system consisting of synchro-generator and synchro-control transformer has the same feature of eliminating the need for a separate error detector. The same applies to bridge-type circuits composed of inductance or capacitance elements which can be controlled by mechanical motion applied to movable elements. If, however, independent voltage sources are used as translators (s_1/x_1) and (s_2/x_2), the translator voltage must be applied to an error detector which, in many cases, may be incorporated in the "amplifier". A number of circuits are available which will compute the difference of two voltages, thus producing the desired error signal.

A system according to *Fig.* 15 develops an output torque determined by the motor design. It is immediately applicable to positioning problems presenting a load torque up to the rated motor torque. If higher load torques are to be handled, one can of course select a larger motor and redesign the amplifier for increased power output. Another approach, however, makes use of the standard system, *Fig.* 15, and adds another stage of torque amplification in order to obtain the desired output torque. This follows the customary procedure of amplifier design providing for a power output stage after initial voltage amplification. A system of this kind is shown in *Fig.* 16.

The first stage is identical with the previous system of *Figs.* 14 and 15. The output stroke of the first stage, however, is now applied to the second or power stage, which is an independent hydraulic stroke translator in itself. The final output stroke will again duplicate the orig-

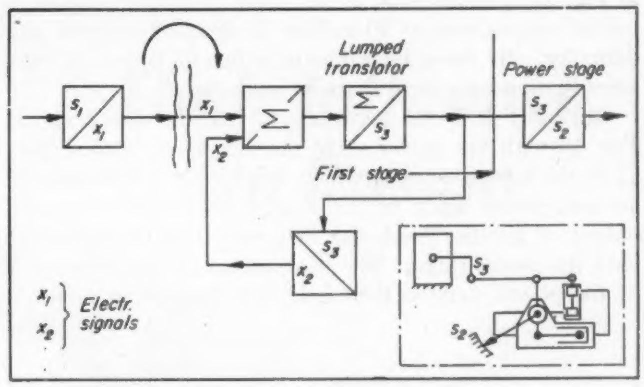
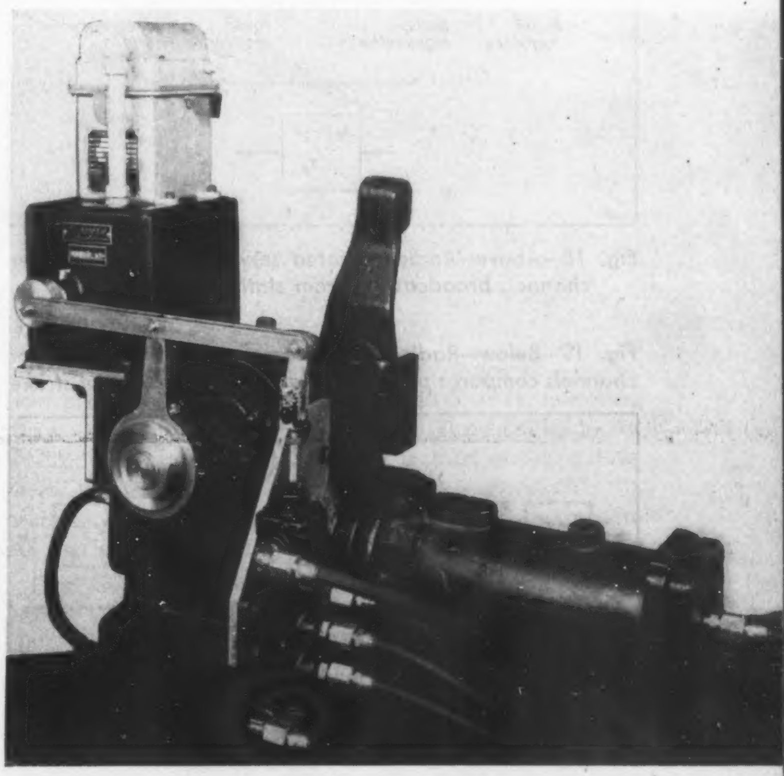


Fig 16—Above—Servo with additional power stage

Fig. 17—Below—Power stage (s/s) translator of lower right-hand corner of Fig. 16



inal input stroke, but at a greatly increased power level.

The two-stage approach offers a number of attractive features. The standard system, used as first stage, can be built with increased power output without any changes in its design. The value of the power stage, which may be selected from a variety of standard models, is enhanced by the addition of the remote control properties of the first stage. The combination of two independent systems allows for great flexibility in design.

In actual design it is advantageous to combine in one unit the power stage with the first stage. An example is given in *Fig.* 17, which shows a hydraulic power cylinder with pilot valve combined with the receiver, as diagrammatically shown in the right-hand lower corner of *Fig.* 16.

A look at actual torque values involved may serve to indicate the potentialities of systems of this kind. The input torque required to move the input translator (s_1/x_1) may be of the order of 0.003 oz-in. The output torque obtained from hydraulic power cylinders of the type shown in *Fig.* 17 is about 4000 lb-in. Thus, a torque amplification of approximately 20 million is obtained without any difficulty. By using hydraulic cylinders of larger size this amplification ratio is practically unlimited.

Obviously it is not necessary to link the first stage of *Fig.* 16 with the power stage through a mechanical link.

By the use of a relay, which is basically a translator of an energy-rate input of one energy level into an energy output of another level, the first stage can be connected with the power stage. The final output of the power unit of the power stage is then fed back through an intermediate translator (s_2/x_2), obviating the mechanical link.

This is basically the circuit of *Fig.* 14 with the exception that the translator

$$\left(\Sigma x \Big/ \frac{d\ \text{Energy}}{dt}\right)$$

consists of two translator boxes.

An example of this type of servo is shown in *Fig.* 1, in which a hydraulic motor (crank cylinder) is getting its energy supply through two solenoid-operated valves. The electric energy supplied to energize the solenoids is translated into corresponding energy flows of oil under pressure. Another modification of purely electrical nature is the use of an amplidyne which serves to raise the energy flow level from a relatively low watt input level to practically unlimited values.

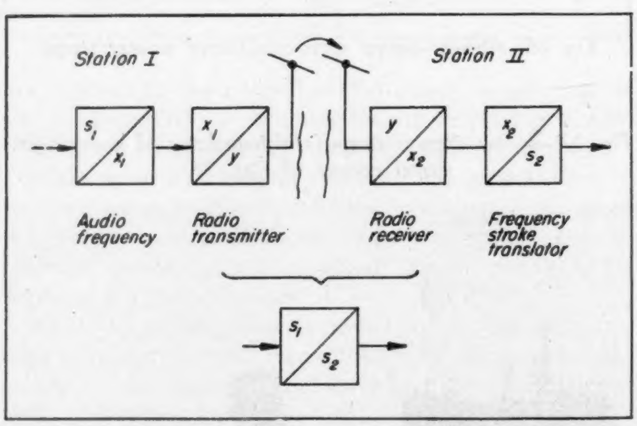
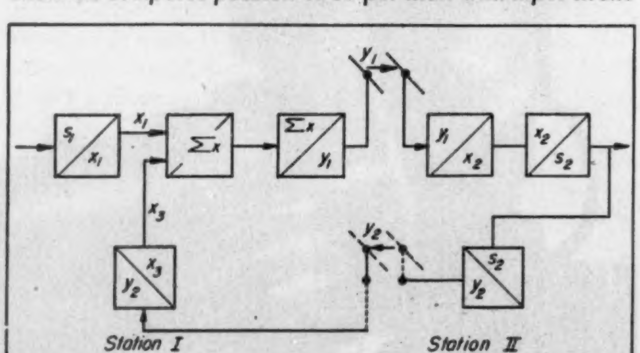


Fig. 18—Above—Radio-operated servo with one translator channel, broadcasting from station I to station II

Fig. 19—Below—Radio-operated servo with two translator channels compares position of output shaft with input stroke



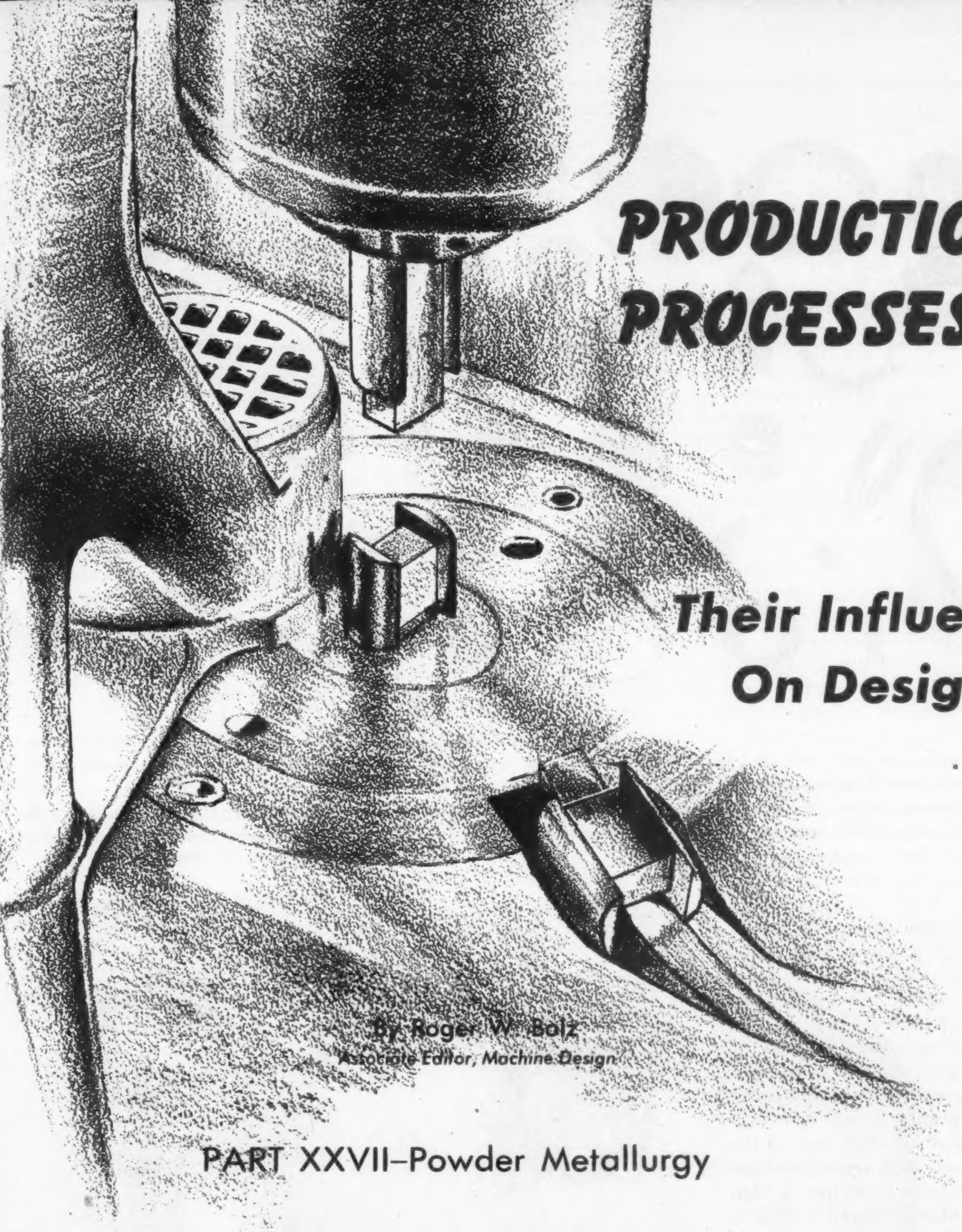
Distance Should Not Disturb Circuit Balance

All systems discussed so far require some electrical connection linking the remote input and translator (s_1/x_1) with the remaining units. Basically, the possible length of this line connection is determined by the equipment which the modern wire communication technique has to offer, and may extend over thousands of miles. It will be appreciated, however, that the line itself is an additional circuit element and that, for longer distances, the translators must be selected so that the line characteristics will not disturb the correct balance condition. To put it another way, the value of x_1 must not be affected by the transmission over the distance between transmitter and receiver. In certain applications, however, as in systems involving moving vehicles, any wire connection becomes impossible and a radio link has to be established between the input and output stations.

A basic solution of the problem is shown in *Fig.* 18. Here an audio frequency was chosen as the signal to be broadcast from station I to station II. Station I consists of a translator which converts the input stroke into a corresponding frequency, and of a radio transmitter which sends out a radio signal modulated with this frequency. Station II contains a radio receiver which reproduces the audio frequency at the remote point. This frequency is then applied to a (frequency/stroke) translator built of similar elements as the first translator and producing an output stroke identical with the input stroke. The radio system of *Fig.* 18 is similar to the earlier system of *Fig.* 16 inasmuch as it consists of two independent systems translating input stroke into frequency, station I, and frequency into output stroke, station II. Only a single radio channel is required.

If it is desired to observe at station I whether station II performs correctly, a radio system related to the principle of *Fig.* 16 may be designed which uses two radio channels and therefore two transmitters and receivers, *Fig.* 19. The position of the output shaft in station II is then to be rebroadcast to station I, compared with the desired position, i.e., input stroke, and an error detector causes a signal to be broadcast to station II whenever a correction of the output shaft is required.

The author is greatly indebted to his company's chief electronic research engineer, Paul Glass, for many suggestions while preparing the electrical part of this article.



PRODUCTION PROCESSES...

Their Influence On Design

By Roger W. Bolz
Associate Editor, Machine Design

PART XXVII—Powder Metallurgy

FOR lack of a better, more concise term for the pressing and sintering of metal powders into machine parts of all varieties, the generally recognized one "powder metallurgy" is normally employed. Although not always considered as such, powder metallurgy is a production process and recent developments in technique have advanced it to a point where it now must be ranked alongside the many others covered in this series.

Historically, powder metallurgy antedates most other methods, the first actual recorded experiments being those of Wollaston in 1829. Continuous research led to the first practical commercial use in producing tungsten wire in 1916. The first porous metal bearings were marketed just following World War I, but in the ensuing years improvements and new applications developed at a rather slow pace. With the outbreak of World War II, however, the vast potentialities of powder metallurgy began to be realized for its value not only as a method of fabricating parts whose physical characteristics are impossible to produce otherwise, but a large-volume mass-production process having excellent speed and material economy.

Successful applications of parts produced from metal powders to date are rather impressive. Beyond the well-known oilless or self-lubricating bearings and like parts, there lies a tremendous field of machine parts which, with the particular characteristics available through powder metallurgy, can be redesigned to achieve greatly improved performance, longer service life, simplified design and

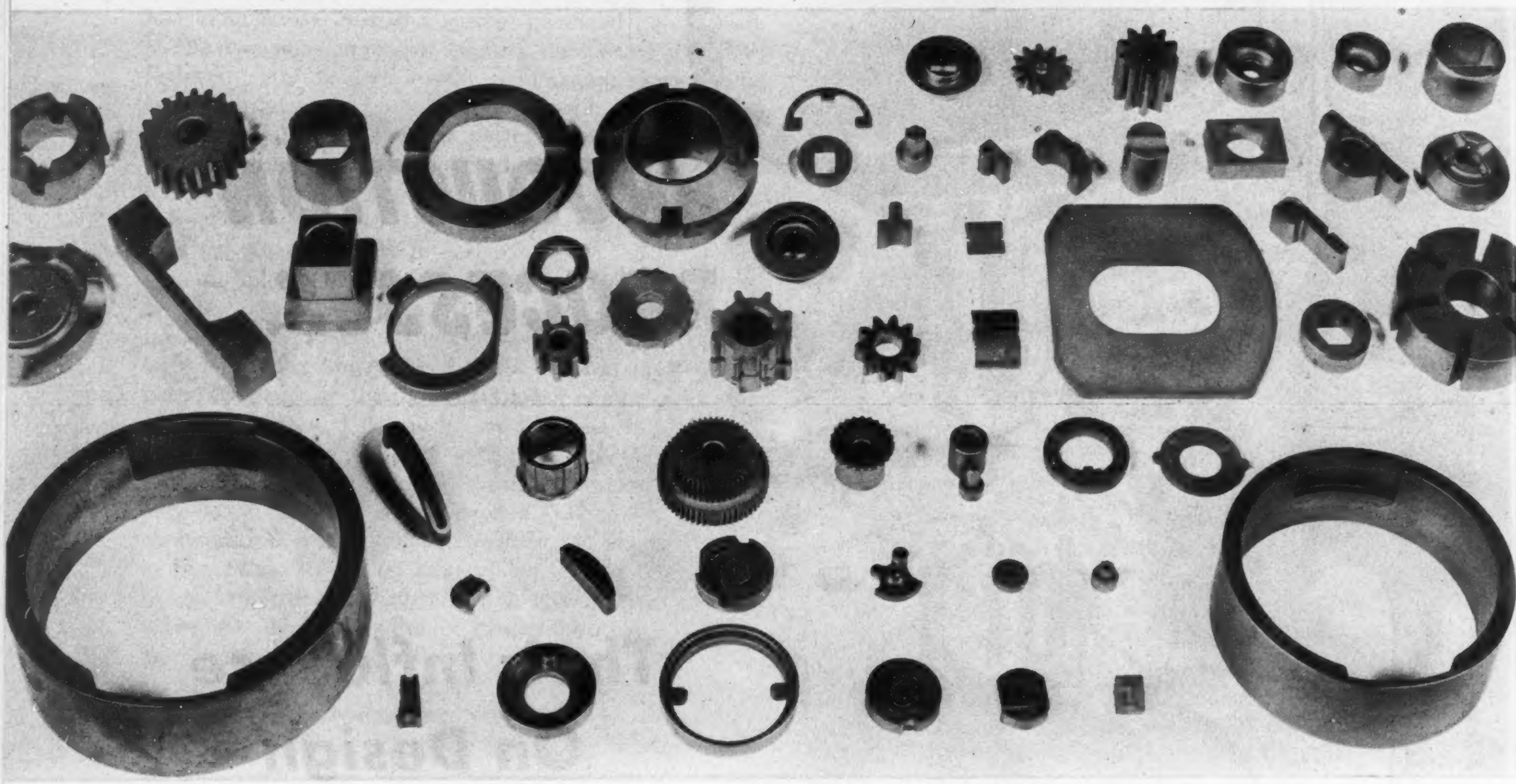


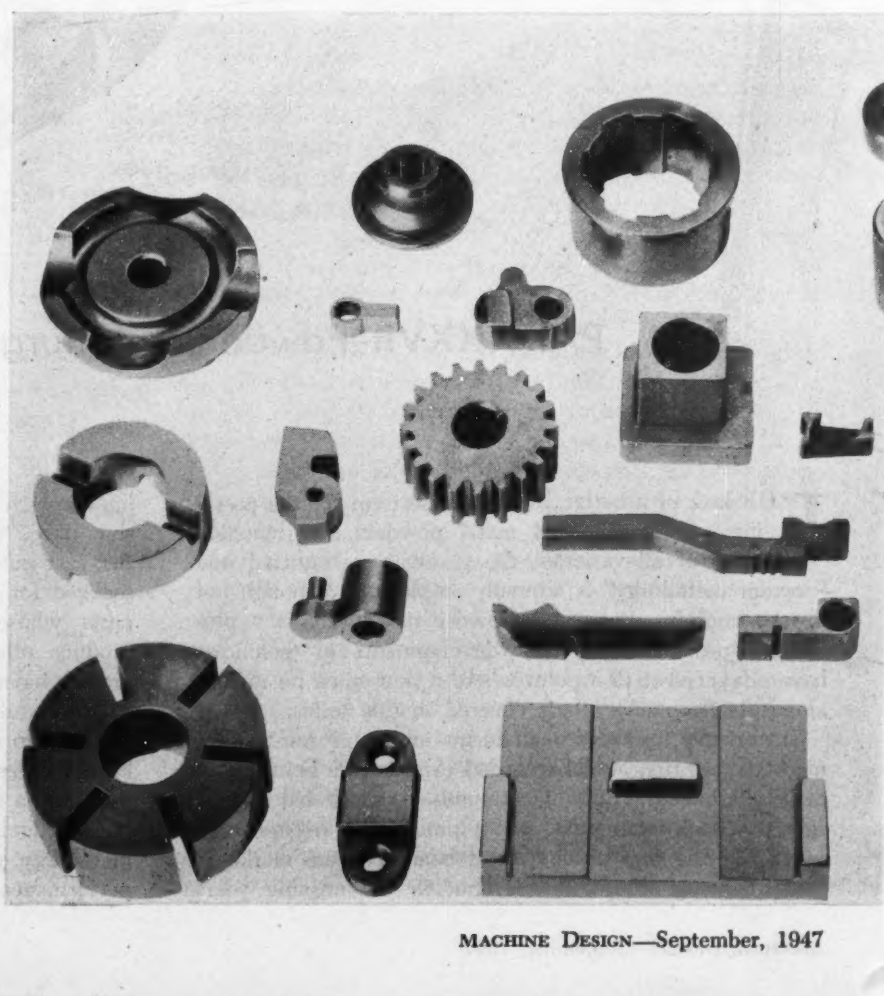
Fig. 1—Above—Group of representative precision machine parts produced by powder metallurgy

manufacture, lower cost per part, etc. Representative of these are external and internal gears, external and internal ratchets, levers, sliding blocks, cams of all varieties, clutch friction facings, internal and external splines, rollers, guides, permanent magnets, piston rings, bushings, turbine blades, small clutches, spacers, etc., *Fig.* 1.

A variety of methods can be utilized to produce end products from metal powders as well as from combinations of metallic, nonmetallic, and intermetallic powders. Several general classes can be set up, the first in which consolidation during sintering is primarily a particle-to-particle cohesion or the contact fusion of particles containing a melting constituent, the second in which one of the powders used acts as a melting medium bonding or cementing together a high melting-point constituent, and a third in which consolidation of a fairly high melting-point metal is achieved as in the first category but, lacking high density, the compact is impregnated with low melting-point metal.

Various steps in the procedure which may be employed in producing parts are generally as follows: (1) Selection of the powder or powders best suited for the part being designed as well as for the most rapid production; (2) wet or dry mixing of powders where more than one powder is to be used; (3) pressing in suitable dies; (4) low-temperature, short-time sintering usually referred to as presintering for increasing strength

Fig. 2—Below—Parts best suited for production by means of powder metallurgy cannot be produced at all or economically by other methods



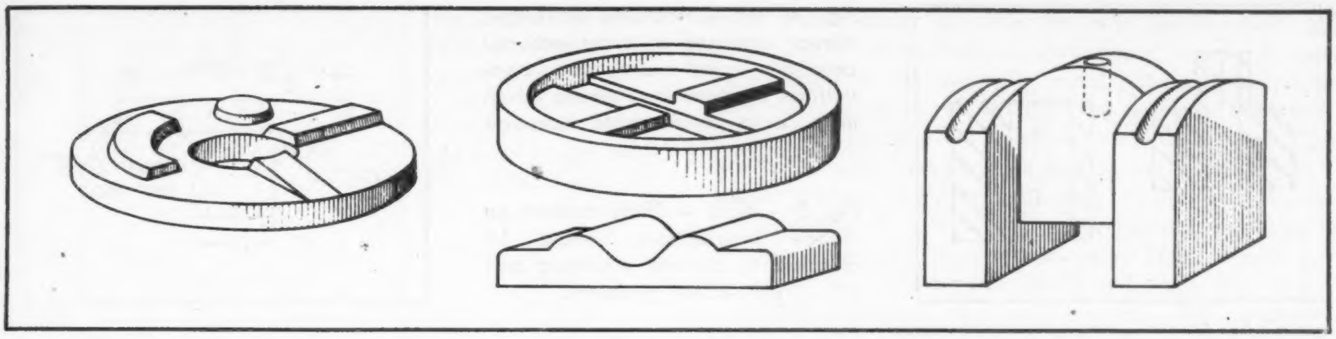
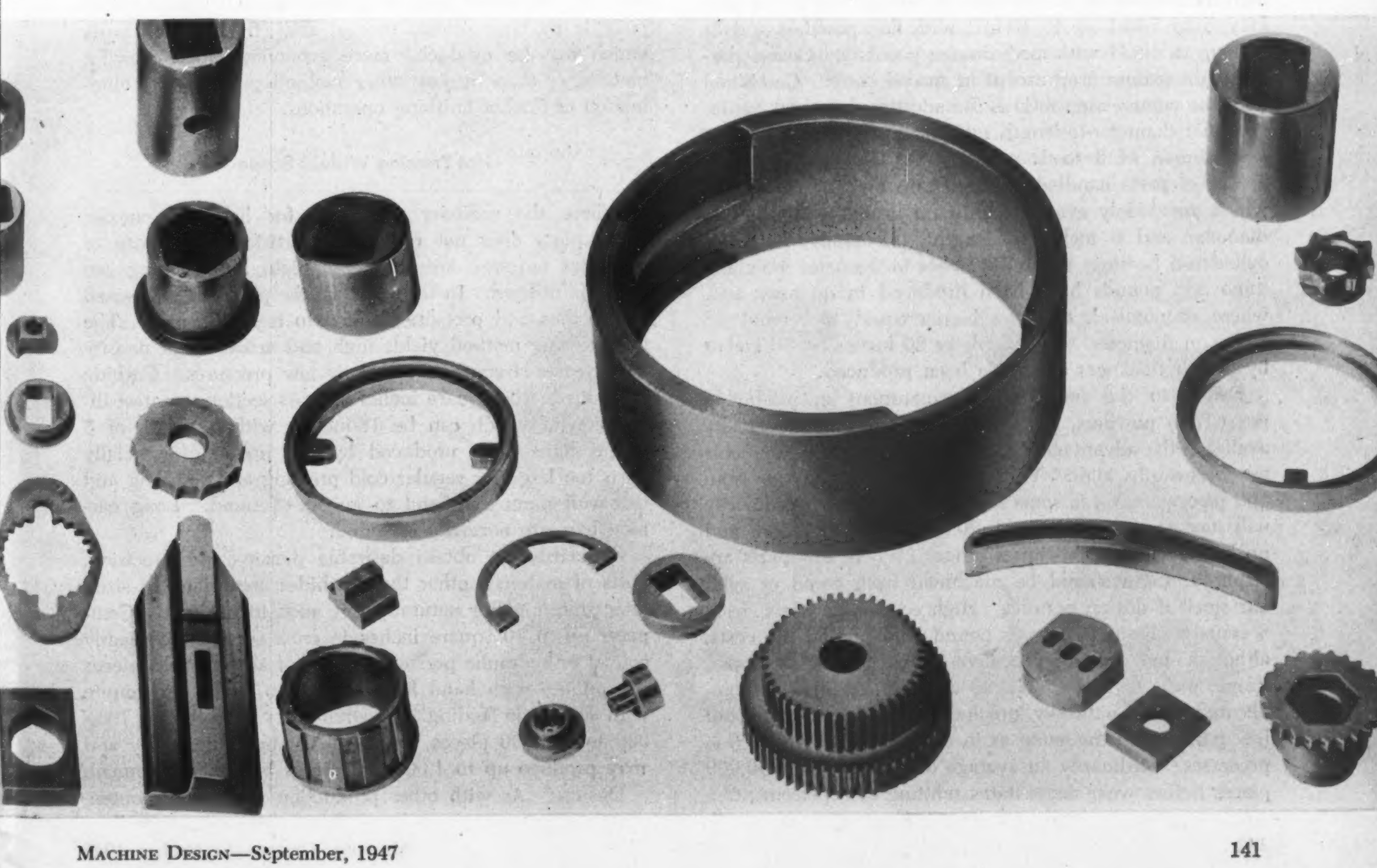


Fig. 3—Axial projections, complex shapes, slots, grooves, blind holes, and recesses are easily obtainable so long as such design details can be produced by the action of one punch or two opposed punches

of fragile parts, removing lubricants, etc.; (5) machining or otherwise forming of presintered parts; (6) sintering green compacts or presintered parts to obtain the desired mechanical properties such as proper density, hardness, strength, conductivity, etc.; (7) impregnating operation for low-density sintered compacts, usually by dipping in molten metal so as to fill all pores; (8) coining or sizing operation, cold or hot, when necessary to attain more exacting dimensional tolerances and also improve properties; and (9) a hot-pressing operation to replace the usual pressing and sintering.

Most commonly used commercially is the plain cold pressing and sintering cycle. Presses may be mechanical, hydraulic or a combination of both. Generally, small parts which can be made at high speed with relatively low pressures are best produced in mechanical automatic presses with single or multiple-cavity dies. Such presses for average parts, say up to 6 inches in diameter, have an output from about 200 to 1600 parts per hour using a compacting pressure of approximately 10 tons per square inch. Small bushings have been produced at a rate of 12,000 pieces per hour, and certain simple machine parts at speeds as high as 30,000 per hour using a dial-feed arrangement. These presses are either of the single-action type which compresses with the top punch only, or of the double-action type which employs movement of the lower punch simultaneously with the upper to obtain more uniform compacting and for automatic ejection.

Where parts are of large size or when maximum uniformity in density is necessary and maximum speed is not so essential, hydraulic presses are employed. Parts with approximately 12 to 14 square inches of area, pressed at 30 tons per square inch, have been produced at a rate of 1200 pieces per hour on a 375-ton press. As a rule hy-



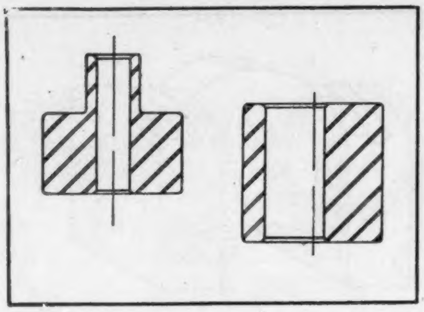
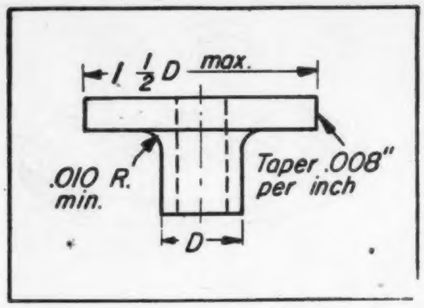


Fig. 4—Left—Limitations on large, abrupt changes in cross-sectional area are based mainly upon non-uniform changes in sintering which may cause considerable warpage

Fig. 5 — Right — Sharp corners on flange intersections should be avoided to obviate weakness and production problems



draulic presses range up to 500 tons capacity although the great bulk of machine parts are produced on presses falling within the 5 to 200-ton range. Average powder metal work requires anywhere from 5 to around 100 tons per square inch and an average of 30 tons per square inch for pressing or compacting, so the broad limitations on size of parts which can be handled is readily apparent. It is interesting to observe, however, that the final density of a powder metallurgy product is not determined by the pressure under which it is cold-pressed or briquetted. Rate of pressure application, particle size, type of material, sintering time and temperature, occluded gas, etc., also have their effect upon final density and size.

Press Stroke Limits Length of Parts

Press stroke also poses certain broad limitations as to part size. The compression ratio between the volume of powder in a die before and after pressing is dependent upon loading weight, particle size, form and composition, metal hardness, and pressure utilized. With most common metals and alloys this ratio is usually 3-to-1, but may vary from 5-to-1 up to 10-to-1 with fine powders and 2-to-1 up to 4-to-1 with medium-size powders. Coarse particles are seldom used except in special cases. Combined with the compression ratio is the additional general limitation that diameter-to-length ratio of parts be restricted to a maximum of 3 to 1.

Size of parts handled in presses up to 75-ton capacity, which are widely available, runs up to about 5 inches in diameter and 6 inches in length. Generally, however, cylindrical bearings up to 18 inches in diameter weighing some 233 pounds have been produced in quantity and, where economical, this can be increased to around 36 inches in diameter. Bronze plates 20 inches by 30 inches by 1-inch thickness also have been produced.

Owing to the speed of the operations in producing parts from powders, quantities which make economically available the advantages possible by means of this process are necessarily high. Volumes ordinarily may run from 500 pieces and up in some few special cases but ordinarily will start at about 5000 with 20,000 to 50,000 pieces and up being a good economical range. Where few parts are required, these should be machined from cored or solid bar stock if design permits. High cost of powders, from 8 cents to about $1.00 per pound, and normal die costs, although not usually excessive—about $150 for small, simple parts to perhaps $1800 or more for large or complicated ones—naturally preclude the production of but few parts much the same as in the other high-production processes. Ordinarily an average die will produce 50,000 pieces before wear necessitates refitting or replacement.

To properly assess the advantages which give powder metallurgy its greatest value as a production method, it should not be considered generally as a competitor of other methods. Competition on an even basis with other methods may even be unwise; powder metallurgy should yield a distinct contribution, and should be considered primarily for parts which either cannot be produced by other methods at all or which cannot be produced economically, *Fig.* 2. In general, a few of these specific applications are: (1) Production of solid ingots or parts from highly refractory metals such as tungsten, tantalum, columbium, and molybdenum which cannot be fused commercially in available furnaces; (2) parts from several materials of divergent characteristics, and which do not alloy in the molten state, including metallics, intermetallics and nonmetallics, which combine to give a product which retains each material's desired characteristics; (3) precise dimension parts so hard or brittle as to preclude any other means of shaping; (4) parts with characteristics unobtainable by other methods, such as controlled porosity, extremely high density, frictional characteristics, controlled inductance, etc.; (5) laminated parts with more intimate binding than possible by conventional means; and (6) precision parts which can be produced more economically by powder metallurgy than by any other method primarily by elimination of further finishing operations.

Hot Pressing Widens Scope

Where the ordinary procedure for handling powder metal parts does not result in a satisfactory density or pressures required are extremely high, hot pressing can often be utilized. In this method, the powders are heated in the dies and pressure applied to form the part. The hot pressing method yields high and nearly ideal density and greater strength at relatively low pressures. Carbide parts up to 100 square inches in cross section, greatest dimension of which can be 18-inches, with a length of 8 inches have been produced by hot pressing, especially parts too large for regular cold pressing and sintering and thin-wall parts that tend to go out-of-round. Long carbide bars are normally extruded.

Ordinarily, to obtain desirable density and precision, parts of materials other than carbides are coined or sized after sintering but naturally this adds to the cost. Compacts up to 10 square inches in cross section are readily coined in hydraulic presses at a rate of about 4 to 6 pieces per minute with hand feeding and up to 10 per minute with automatic feeding. Generally dies will produce 100,000 to 200,000 pieces before refinishing is necessary and may produce up to 1,000,000 pieces before replacement.

DESIGN: As with other production processes, econom-

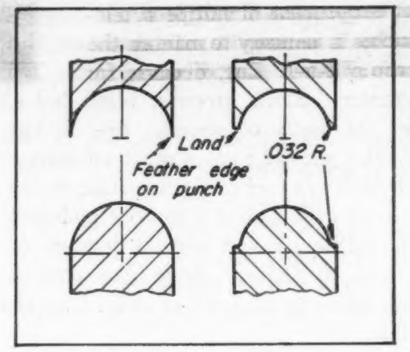


Fig. 6—Parts pressed with a radius on the punch should be designed to have a small land to avoid premature tool breakage

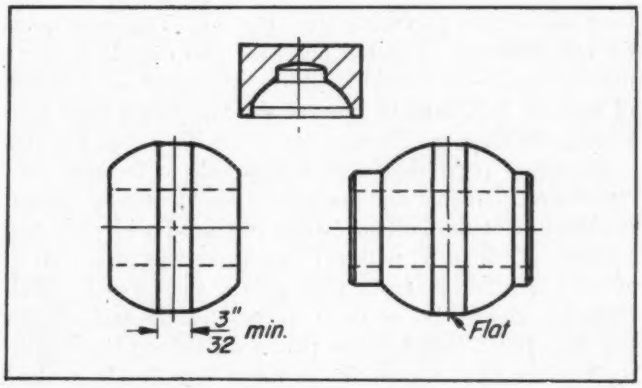


Fig. 7—An approximate design for spherical surfaces permits simplified tooling and extends tool life considerably

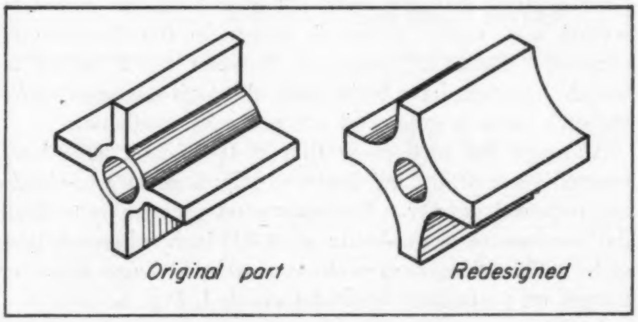


Fig. 8 — Above — Narrow radial splines should be avoided to guard against poor density and weak punch design

ically sound design of parts demands consideration and adherence to certain inherent limitations present. It must be remembered that normally metal powders lack plastic flow when subjected to pressure and specially those with a high flow factor—that is, slow flow—make even filling of a die difficult and give rise to bridging, especially with narrow sections, with resultant wide variations in density. Consequently, limitations of form are inherent in design of powder metal parts; it is impossible to press powder into re-entrant angles, sharp corners or undercuts, *Fig.* 3.

Reliefs, undercuts, etc., on either the inside or outside of a part are beyond the capabilities of present-day equipment, and although much study has been given this problem, equipment necessary is economically unfavorable. Ordinarily pressure cannot be applied from the sides but only from the top and bottom of a die so such features which cannot be built into the upper and lower punches cannot be employed. This eliminates internal or external threads as well as holes or bosses normal to the axis of pressing and such features, if required, must be produced by a secondary machining operation.

Owing to the almost negligible flow of the powders, large and abrupt changes in section or thickness as well as unsymmetrical cross sections should be avoided to guard against variations during sintering, *Fig.* 4. Sharp corners at points of intersection are detrimental, a minimum radius fillet of 0.010 to 0.015-inch should always be specified on internal corners, *Fig.* 5. Again, however, too large a fillet also causes some difficulty. All corners should be beveled 0.010 to 0.015-inch minimum, to avoid formation of flash or fins but bevels should not be too large to obviate punches with fragile, feather edges. Parts with a radius should have a small land at the edge to avoid the same characteristic, *Fig.* 6. It is well to remember, though, such curved designs, *Fig.* 6, are particularly difficult to handle inasmuch as they require considerable loose powder and plastic flow. Where spherical portions are employed, an approximate design is preferable to increase tool life and simplify tool design, *Fig.* 7.

Parts with radial projections and recessions, *Fig.* 8, must be carefully designed to avoid bridging of the powder fill

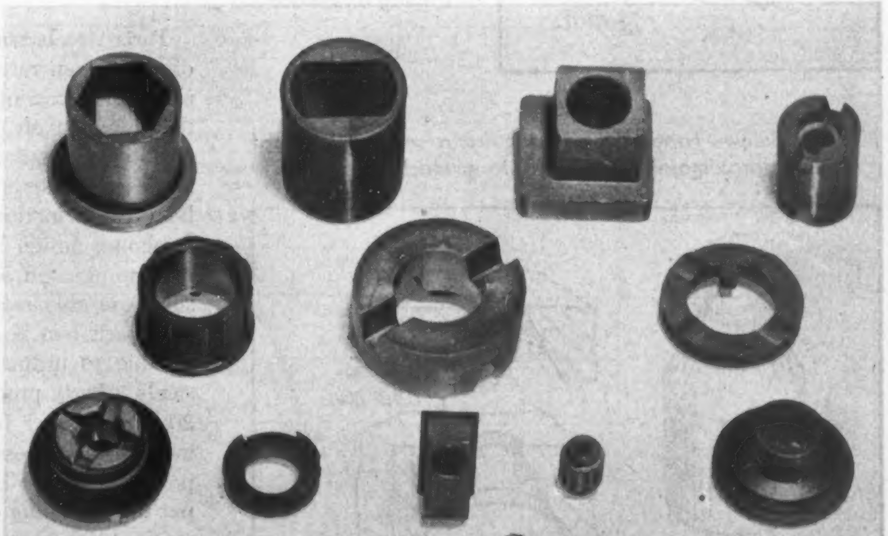


Fig. 9—Right—Slots, grooves, blind holes, keys, etc., are particularly economical in relation to similar characteristics produced by other processing methods

across narrow splines which gives rise to density variation, weakness and ejection difficulties. Too, parts having narrow splines may result in early die breakage owing to the high pressures usually involved and consequently the designer should always strive to assure maximum possible punch sections for greatest die life. In addition, whenever part tolerances permit, taper of cavity side walls from 0.0005-inch per inch and up should be allowed to reduce ejection difficulties.

As a general rule, parts in which axial variations—bosses, projections, recesses, etc.—are not greater than ¼ the overall length of the body of the part are practical and considered "naturals" for this process. The primary reason for this is that such parts can be produced by a single upper punch with sufficiently uniform density to satisfy general requirements. Where variation is greater

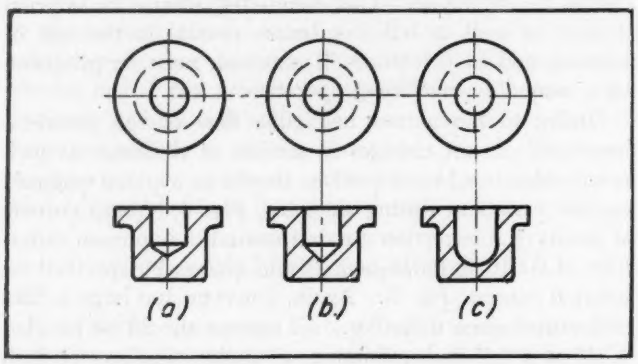


Fig. 10—Above—Minor design alterations, b or c, permit economical production of blind holes

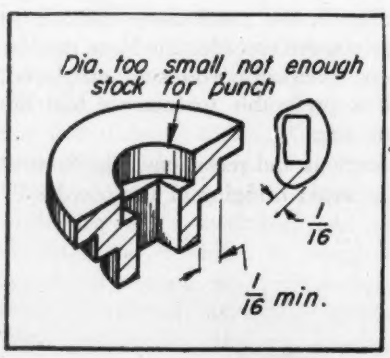
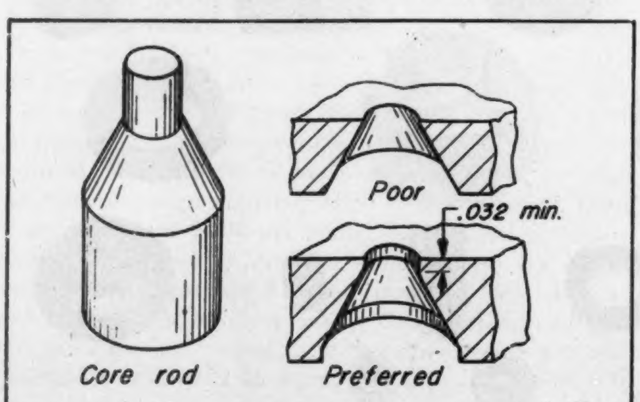


Fig. 11—Left—Steps should be at least 1/16-inch or greater; the internal counterbore shown would have to be increased or produced by machining afterward

Fig. 12—Below—Tapered holes require a small cylindrical land approximately as shown to protect the punch



than ¼, the mechanical compensation of multiple or telescoping compound punches is necessary to maintain the average compression ratio of 3-to-1. Cost, of course, for such tools is much greater. Slots, grooves, blind holes, and other irregularities are easily obtainable, *Fig.* 9, but wherever possible the sides should have a draft allowance of approximately 0.008-inch per inch, *Fig.* 5. Hole depth can be held the same as in drilling but a smaller included angle at the bottom should be allowed, say 90 degrees, or a rounded punch tip, *Fig.* 10. Also, a draft allowance of 0.001-inch per inch minimum in such cases should be allowed whenever possible.

Where stepped shoulders are contemplated, each step preferably should be at least ⅛-inch greater in diameter than the body or preceding step, *Fig.* 11. The same holds for counterbores. Tapered holes are also easy to produce but the small end should be made cylindrical for a length of at least 1/32-inch to prevent the top punch from contacting the taper on the core rod of the die setup, *Fig.* 12.

Length of parts should be comparable to the cross-sectional area, overlong sections exhibit low density at central positions or at the bottom (when produced with only one punch). Ordinarily, with cylindrical sections, it is well to avoid a length-to-diameter ratio greater than 3 to 1. Wall thickness should be as great as practicable and seldom less than 0.062-inch because thin walls reduce the length-to-diameter ratio necessarily to about 1 to 1. In general practice, a minimum wall of 0.050-inch is recommended for cylindrical sections up to 0.750-inch and proportionally greater as diameter increases. Ordinarily, production has been confined to parts with not over 8 square inches of section area and 3 inches in length in the direction of pressing. Parts 12 inches in diameter by 9 inches in length, however, have been made although the press stroke for such parts is great and not generally available.

Although flat sections as thin as 0.015-inch have been pressed successfully, coining is usually necessary to obtain the required density. Recommended practice is to limit flat sections to a minimum of 0.032-inch wherever possible. Thin flanges as well as extremely large diameter flanges on parts also should be avoided, *Fig.* 5.

Inserts Not Usually Practical

Parts which can be hot pressed will be free from many of the design restrictions normally encountered with ordinary cold pressing and sintering. However, inasmuch as this is relatively new and not widely available designs should be discussed with the producer before completion. As a rule, inserts should be separate; such cannot often be pressed in during the processing. Too, many of the foregoing design limitations can be overcome by resorting to impregnated iron or steel materials. Pressing pressures are only moderate, also much larger and more complex parts can be produced with physical properties comparable to ordinary plain, heat-treated or case-hardened steels. Parts produced run from 3 ounces to as much as 20 pounds and from a design standpoint this particular method of processing offers considerable flexibility. Compound parts can be produced readily by utilizing the copper impregnating operation to braze two or more sintered-steel pieces together to form one high-strength complex part not economically possible by other means.

To effect maximum economy designs should be pos-

sible to complete in the dies. The more additional machining operations necessary, the less favorable will be the economies, *Fig.* 13.

For carbide bushings a wall thickness approximately 15 to 25 per cent of the diameter usually is most economical. Cost of making thin-wall parts is greater than the saving in material. On thin strips a proportion of length-to-thickness between 8-to-1 and 12-to-1 is usually most economical. Beyond this point cost of manufacture increases rapidly. Presintered parts can be machined into a wide variety of shapes and forms prior to final sintering.

MATERIALS: A wide variety of materials is available in powder form for use in producing parts. Most common are probably bronze, tin, brass, copper, iron, iron alloys, steel, carbides, and aluminum. Beryllium, stainless steel, copper-nickel alloys, tungsten, molybdenum, tantalum, zinc, and in fact almost any of a wide variety of the common alloys are available. In addition, of course, are the nonmetallics such as silicon and graphite.

Powders having particles over 100 mesh or 150 microns in diameter are rarely used. Generally, the range of particle sizes is always below 150 microns and upward of 50 per cent of the powder will be below 45 microns. Powders behave very differently, even when of the same material, so uniformity of mix is essential for uniform characteristics of parts. Hard powders are difficult to press while soft powders are much easier to handle. Powders which work harden also are more difficult to press and may require an annealing operation.

Production powder-metal parts generally have relatively low elongation, tensile strength, and impact strength when compared to similar parts made from cast, forged or wrought materials. For most applications this is not a handicap and properties available are sufficient. Indications are that before long equivalent properties will be available and at present this is the case with copper-impregnated iron pressings. The average values shown in the table of general physical properties for some of the sintered powder compacts indicate what can be expected.

As previously mentioned, hot pressing achieves optimum physical properties from the materials pressed and especially so where work hardening, poor flow or hardness is present. Impregnating porous presintered steel compacts achieves optimum density with low-pressure pressing and is ideal especially for larger parts and those too complicated to produce in one pressing. Naturally, small parts present a handling problem and seldom offer reasonable economy compared to simple pressing and sintering.

Aluminum has been used most generally for bearings. Demand for machine parts, however, has been somewhat limited. Beryllium has also been employed for small machine parts; the various brasses and bronzes for bearings, filters and screens in addition to a wide variety of machine parts; copper and copper alloys for corrosion-resistant parts, filters, screens, friction disks, etc.; iron in combination with aluminum, nickel and cobalt for magnets and

TYPICAL AVERAGE PHYSICAL PROPERTIES OF POWDER METAL PARTS

Material	Composition (per cent)	Condition	Tensile Str. (psi)	Yield Str. (psi)	Elongation (% in 2")	Density (gm/cc)	Porosity (% by Vol)	Brinell Hardness
Low-Tin Bronze	95 Cu-5 Sn	Fully Annealed	35,000	18,000	17	8		54
Low-Tin Bronze	95 Cu-5 Sn	Work-Hardened	37,000	30,000	4.5	8		71
High-Tin Bronze	90 Cu-10 Sn	Fully Annealed	35,000	22,000	12	7.9		62
High-Tin Bronze	90 Cu-10 Sn	Work-Hardened	38,000	32,000	3.5	7.9		72
Bearing Bronze	90 Cu-10 Sn	Low Strength	10,500	8,000		5.8	28	
Bearing Bronze	90 Cu-10 Sn	Standard	14,000	11,000		6.2	24	
Bearing Bronze	90 Cu-10 Sn	High Strength	16,500	15,000		6.7	18	
Copper		Sintered	19,900-22,700		3-4	7.6		45
Copper		Hot Pressed	42,600-49,700		10-20	8.9		120-150
Low Carbon Steel	.20-.30 C	Fully Annealed	38,000	28,000	8	7		60
Low Carbon Steel	.20-.30 C	Work-Hardened	44,000		2.5	7		80
Low Carbon Steel	.20-.30 C	Heat Treated	55,000		1.0	7		250
Steel-Cu Impregnated	35 Cu. (min)	Presintered & Imp	70-100,000		7-2	7.8	4 (max)	135-245
Steel-Cu Impregnated	35 Cu. (min)	Case carb., quenched and tempered	120-160,000		5-3	7.8	4 (max)	477-601
Steel-Cu Impregnated	35 Cu. (min)	Precip. Hardened and tempered	130-185,000		5-3	7.8	4 (max)	276-427
High Carbon Steel	.87 C	Water quenched and drawn	152,000	132,000	4			245
Electrolytic Iron	Pure	Pressed & Sintered	33,000	15,200	20	7.40		58
Electrolytic Iron	Pure	Repressed	43,000	40,400	7.5	7.55		83
Bearing Iron	90 Fe-10 Cu	Low Strength	12,000	21,000		5	34	
Bearing Iron	90 Fe-10 Cu	Standard	16,000	30,000		5.4	29	
Bearing Iron	90 Fe-10 Cu	High Strength	20,000	36,000		5.7	25	
Parts Iron	75 Fe-25 Cu		40,000	50,000		5.9	24	
Heavy Alloy	90 W-5 Cu-5 Ni	Pressed & Sintered	86,000			16.5		218
Tungsten Carbide	80 WC-20 Co		350,000*	550,000†		13.55		Rock A84.5-87
Tungsten Carbide	97 WC-3 Co		170,000*	850,000†		15.25		Rock A92.7

*Transverse Rupture Strength in psi. †Compressive Strength in psi.

pure for machine parts, magnetic cores, radio and electronic parts, etc.; heavy metal for radium containers, in rotors of gyroscopes and as counterweights in machines.

The various irons and steels can usually be handled much the same as ordinary parts as far as heat treating, case hardening, hardening, tempering, and drawing are concerned. It is well to remember, though, some of the accuracy inherent in the process may be sacrificed on such treatment. Copper-impregnated iron and steel parts can also be precipitation hardened.

Porosity of the various materials can be accurately controlled in production and can usually be varied from about 5 to 50 per cent.

TOLERANCES: Inasmuch as the economy factor of powder metallurgy is directly influenced by the tolerances to be met, these should be as liberal as possible to extend normal die life to the maximum. Ordinarily, on parts merely pressed and sintered, it is possible to hold radial dimensions to plus or minus 0.0015 to 0.002-inch per inch, providing sections are fairly uniform and shape not too complicated. Length tolerances—along axis of pressing—on small pieces can be held to plus or minus 0.002-inch, plus or minus 0.005-inch up to about 1½ inches of length, plus or minus 0.0075-inch up to about 3 inches, and plus or minus 0.010-inch on longer parts. Flange thicknesses can also be held to these length tolerances. Standard concentricity tolerances for sleeves and bearings is normally 0.003-inch total indicator reading below 1.5-inch bore, 0.004-inch to 3-inch bore and 0.006-inch over 3-inch bores.

Closer tolerances can be held by sizing or coining at additional expense. Plus or minus 0.0005-inch per inch normal to the axis of pressing can be held. Concentricity tolerances can be reduced to 0.002-inch total and occasionally to 0.001-inch. Length of parts can be held to similarly closer tolerances also by a coining operation.

For maximum economy parts should be specified to finish toleraces available from the sintering operation or greater, if at all possible, since machining of powder metal parts, though sometimes performed, is not recommended. On secondary operations such as drilling and tapping of holes, threading, addition of features impossible to press, etc., the ordinary machining tolerances apply.

Surface finish tolerances of parts in the as-sintered form should be accepted wherever possible to achieve maximum economy. Finish in the as-sintered form is unusually smooth and shiny, *Fig.* 14, and excepting those cases where impregnants are used, some degree of porosity usually exists but is not detrimental to operation or service. In fact, the value of this characteristic for lubrication purposes is perhaps the best-known feature of the powder metallurgy process. Where coining is employed as a final operation surface finish is excellent and porosity hardly discernible.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:

Amplex Div., Chrysler Corp. (*Figs.* 1, 2, and 9) ..... Detroit
American Electro Metal Corp. (*Figs.* 7 and 10) ..... Yonkers, N. Y.
Bound Brook Oil-Less Bearing Co. ..... Bound Brook, N. J.
Carboloy Co. Inc. ..... Detroit
Johnson Bronze Co. (*Fig.* 14) ..... New Castle, Pa.
Kennametal Inc. ..... Latrobe, Pa.
Keystone Carbon Co. Inc. ..... Saint Marys, Pa.
Moraine Products Div., General Motors Corp. (*Figs.* 3 and 7) ..... Dayton, Ohio
Presmet Corp. (*Figs.* 5, 6, 8, 11, and 12) ... Worcester, Mass.
Wel-Met Co. (*Fig.* 13) ..... Kent, Ohio

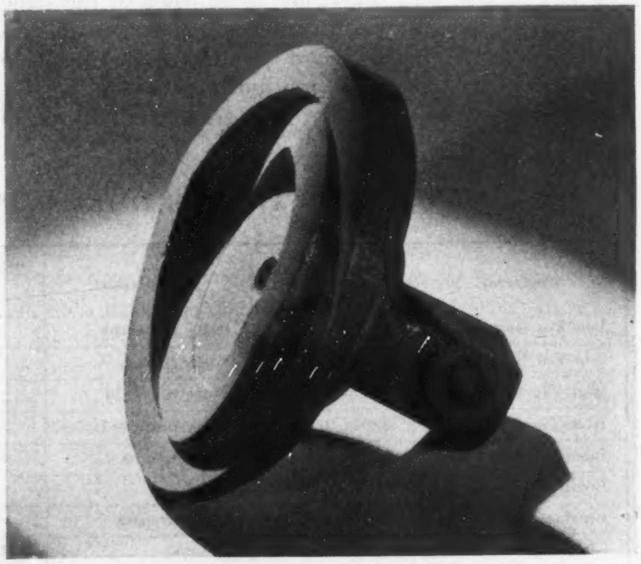


Fig. 13—Above—Combination face cam of iron produced complete by powder metallurgy would present considerable difficulty when made in quantity by other methods

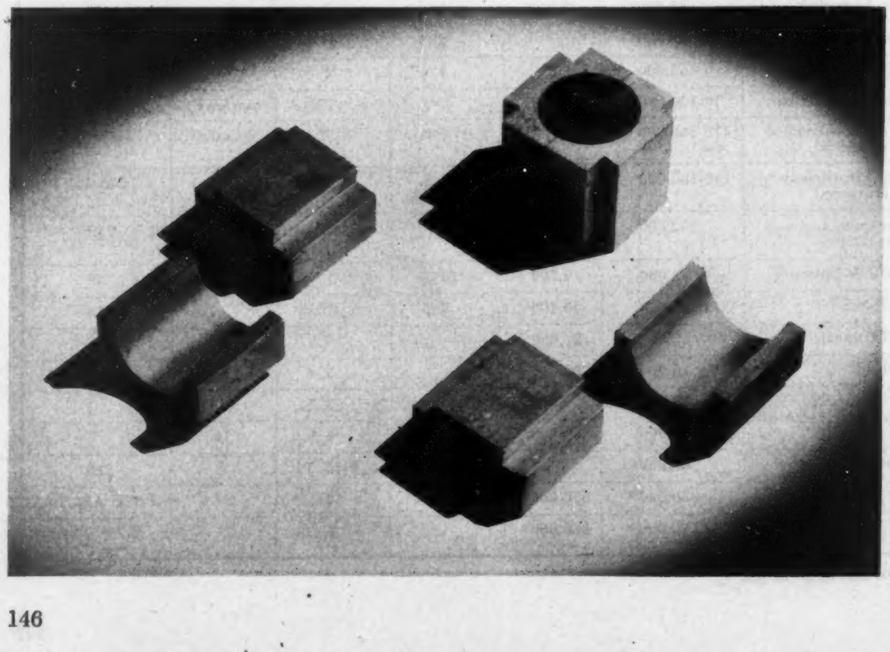


Fig. 14—Left—Ideal for odd shapes, powder metallurgy produces a highly satisfactory surface finish with precision that eliminates all finish machining operations

Universal Control of Induction Heater

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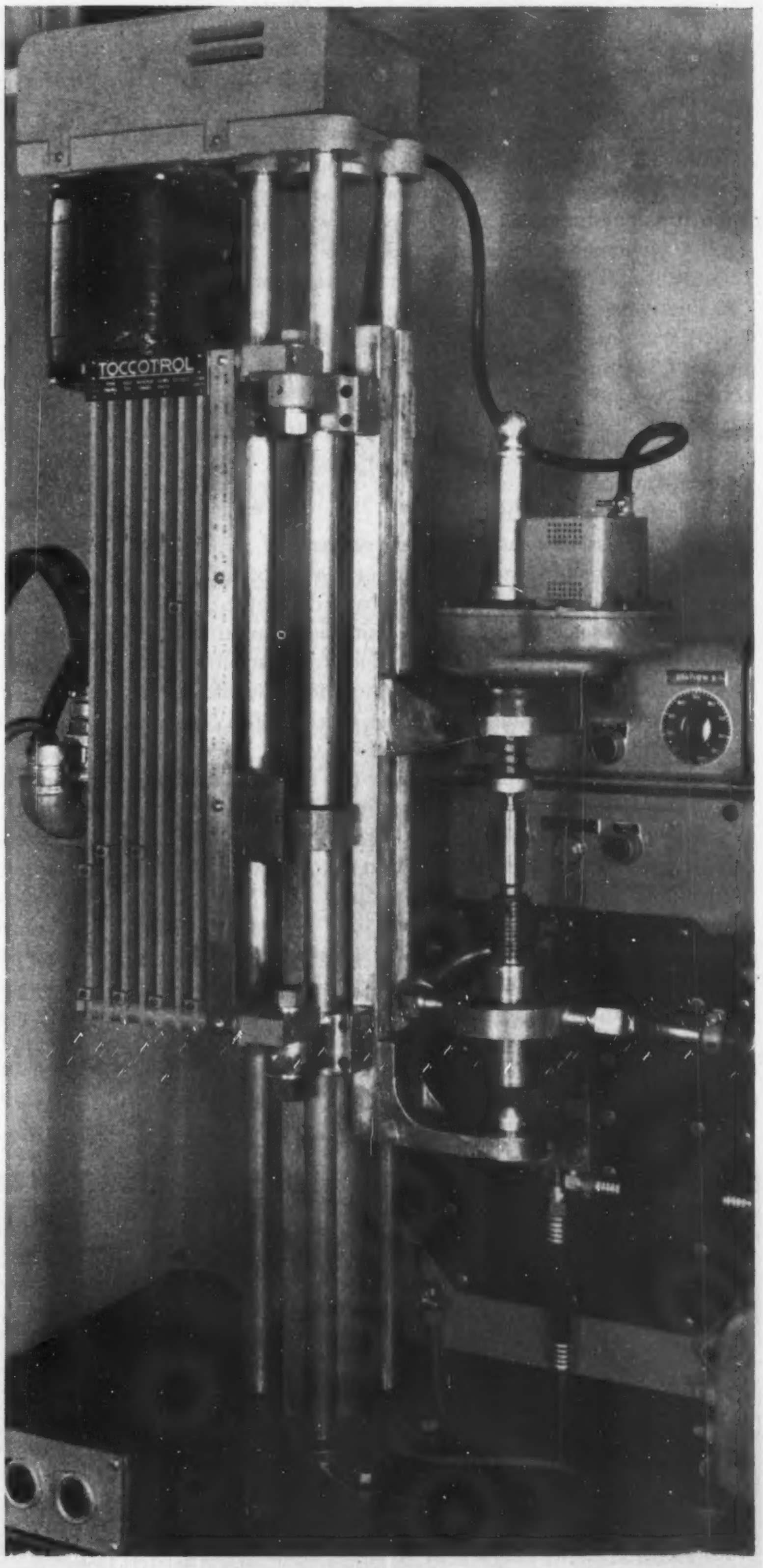


Fig. 1—General view of progressive heating fixture which automatically cycles and controls induction heating operations

PRIOR TO development of the progressive heating fixture shown in *Fig.* 1, it was necessary in induction heating to design a special control each time an additional cam on a camshaft, or an additional bearing surface on a driveshaft, was to be hardened. Then too, many of the fixtures were hydraulically operated and would not consistently repeat themselves when water pressure varied. An expensive pressure control system was required to insure consistent performance.

Since the heat control, quench control, and the timer were electrically operated on the former hydraulic fixtures, it was logical to consider an electrical drive for the vertical motion when designing a new fixture. Because adjustable speed control, speed switching, rapid acceleration, deceleration, and reversing were necessary, an electronic motor drive was chosen.

The unit consists of a control cabinet, a progressive heating fixture and an operator's pushbutton station. A general view of the fixture is shown in *Fig.* 1, while a schematic of the general arrangement and control scheme is shown in *Fig.* 2.

The sequence control timer, located in the cabinet, controls the heat, quench, travel, and delay of travel. The operator's set-up panel contains the necessary set-up switches to enable the operator to choose the automatic sequence control cycle which he desires to use. The set-up panel also contains three speed-control potentiometers. One of these determines the carriage travel in the upward direction and the other two control the speed in the downward direction.

The electronic motor drive unit utilizes standard thy-

ratrons and vacuum tubes, and it operates with an ac input delivering controlled dc to the fixture drive motor. Incorporated in this unit is a current-limiting circuit which keeps the drive motor armature current within a safe value for all conditions of motor loading, even when stalled. The electronic motor drive unit also includes a speed-regulating circuit which automatically holds the main drive motor to its pre-set speed, without the use of a pilot tachometer. Dynamic braking is also included to produce rapid deceleration of the carriage motion. The control relays are utilized in a special "memory" circuit which enables the unit to function for any number of spots or sections to be hardened. All components in the control cabinet have been mounted so that they are easily accessible for servicing, with the main panel of the electronic motor drive unit and the control relay panel being mounted on hinges so that they can be readily swung out of the cabinet.

The progressive heating fixture consists of a movable carriage which slides on three supporting posts and a lift-screw central to these posts driven by a dc motor through a pulley and belt arrangement. A cam rack is mounted on the carriage and the associated limit switches are mounted on the fixture's frame. A rotation motor and its drive mechanism can be attached to the carriage for rotating the piece being treated in applications where rotation is desirable. An outlet is provided near the top of the fixture for connecting the rotation motor which is started and stopped automatically.

The operator's pushbutton station is connected to the fixture and contains only two buttons for "start" and "stop". All functions of the fixture can be initiated and stopped by these two buttons. On jobs set up for automatic operations, it is only necessary to operate the "start" button, because the fixture is self-recycling.

Change from one complete sequence to an entirely different sequence can be effected in a few minutes. The progressive heating fixture can be quickly disconnected from the control cabinet since all connections are made through a compact 26-pole plug. When desired, all connections to the control cabinet can be made through plugs, thus enabling it to be moved readily from one work station to another.

Located on the operator's set-up panel is a "heat" switch. This has been provided so that the operator, when setting up a job, can put it through its entire sequence with the exception of closing the heat contactor. After the set-up is completed and the switch setting is in the "on" position, the heat contactor will be closed automatically at the proper time. The drive motor is protected by a current-limiting circuit which keeps the current within a safe value for all conditions of motor loading. Further, there is a thermal overload which will open after a short time if the motor is left in a stalled condition.

Spot hardening applications, such as surface-hardening cams on a camshaft, can readily be handled. Electrically there is no limit to the number of spots which can be heated on any one piece. The piece to be treated can be loaded either above or below the inductor. It moves into the inductor, motion stops, heat is applied, and the quench is applied. The carriage then moves the piece so that the next spot to be treated is inside the inductor and the same procedure is repeated.

In special spot hardening of gears or pinions, the gear is moved down into the inductor and heat is applied. The gear is then lowered rapidly into a quenching medium for a definite period of time and then withdrawn to its initial loading position. Durations of time that the heat is applied and that the gear spends in the quenching medium are adjustable and are controlled by the sequence control timer.

In progressive hardening applications, such as the surface hardening of bearing areas on a driveshaft, the piece is moved into the inductor and the heat and quench applied while the piece is in downward motion. In other words, the heating and hardening are done progressively.

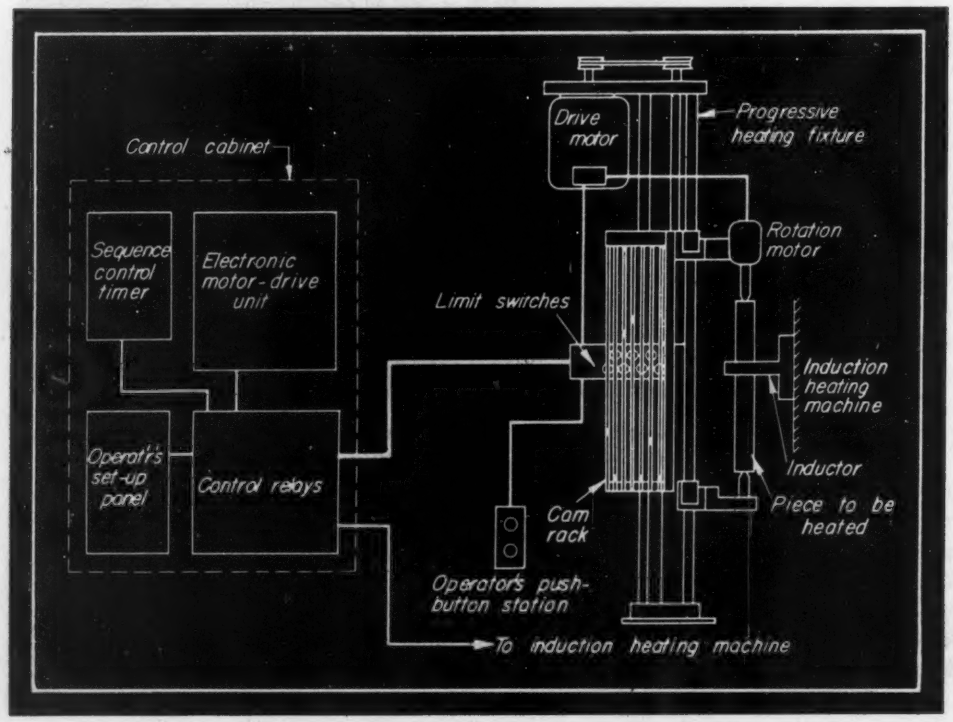


Fig. 2—Block diagram of progressive heating fixture and controls, showing primary units employed

Designer Deserves Tangible Recognition

In his preoccupation with the absorbing problems of his profession the designer has unwittingly allowed others to reap rewards which his work has made possible, while neglecting to see that his own labors are justly recognized.

The machine designer carries a heavy burden of responsibility. Confidence in the success of his design may result in the expenditure of huge sums of money not only for plant, equipment, materials, and labor but also for advertising, selling, merchandising, and other costs connected with distribution. Nowhere along this complex line from designer's brain to ultimate consumer are the decisions of any individual more far-reaching than those made by the designer himself. Yet the key personnel handling certain phases of distribution receive substantial percentages of the business done, in the form of commissions, etc., while the designer must be content with a fixed, sometimes inadequate, salary and often does not even receive the royalties from patents covering his inventions.

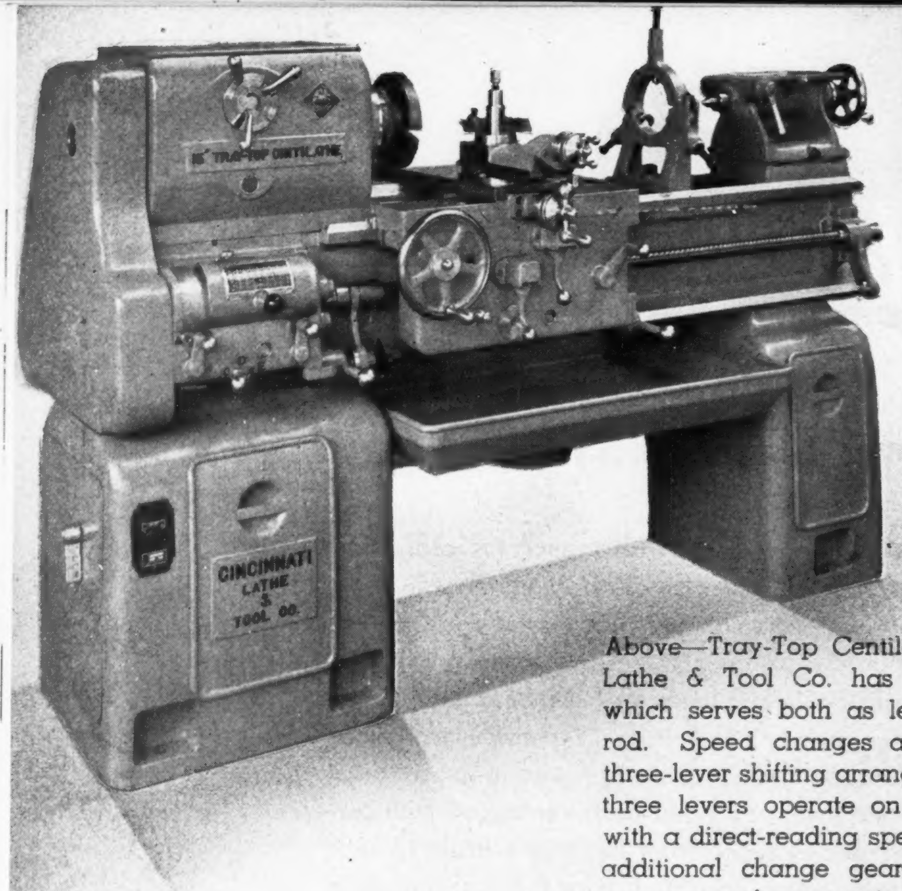
The unfairness of this situation has long been recognized by designers but apparently is rarely acknowledged by those in a position to remedy it. With collective action the theme of the day it would seem natural for designers to unite in attempting to improve their economic status. Instead of indulging in pressure tactics, however, they would serve their interests better by adopting a more professional approach. Here is a great opportunity for the engineering societies to assume leadership by establishing codes of fair practices that would form the basis for employment agreements involving engineering personnel. Such agreements should recognize the right of the engineer to a proportionate reward for invention, whether patented or not, and to a share of the profits resulting from his creation of a commercially successful design.

If engineers were to back their societies to the limit in such a project, the moral force would be overwhelming and the adoption of such a code would be assured. Before this can happen, however, many engineers will have to shake off their skeptical attitude toward their own professional organizations. Instead they should be considering how best they can contribute toward the effectiveness of their societies so that these organizations may become truly representative of the profession.

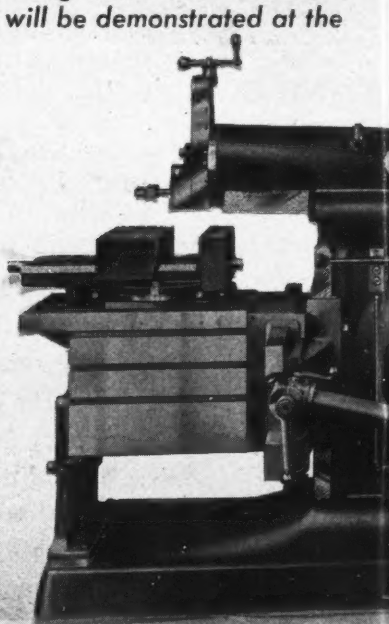
Colin Carmichael

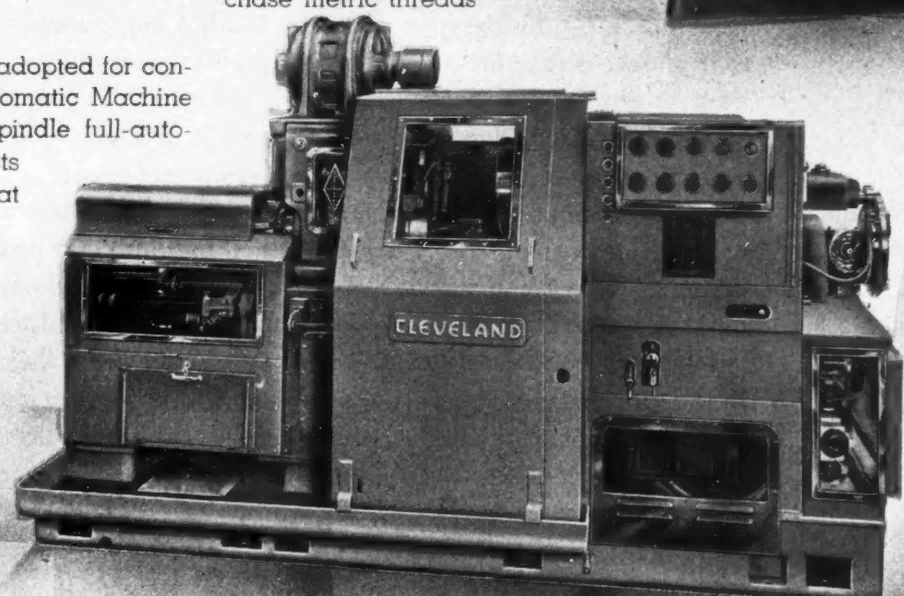
DESIGNS OF TH

Featuring representative outstanding machine tools such as will be demonstrated at the

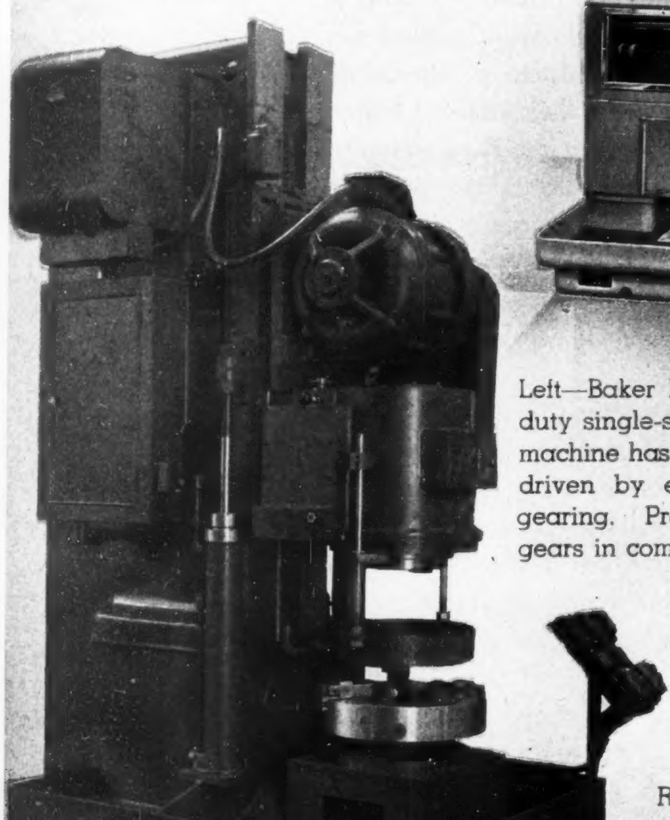


Above—Tray-Top Centilathe by Cincinnati Lathe & Tool Co. has splined leadscrew which serves both as leadscrew and feed rod. Speed changes are obtained by a three-lever shifting arrangement in which all three levers operate on a common center with a direct-reading speed dial. Only two additional change gears are required to chase metric threads

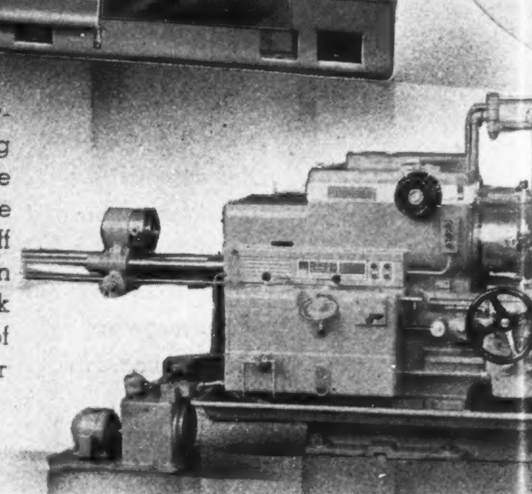




Right—Electric feed drive has been adopted for control of tool feeds on Cleveland Automatic Machine company's "AB" Dialmatic single-spindle full-automatic screw machine. Drive consists of motor-generator set, dc rheostat and rotary selector switch



Left—Baker Model 60-HO-4 extra heavy-duty single-spindle hydraulic feed boring machine has extra large diameter spindle driven by enveloping Cone-Drive type gearing. Provision is made for pick-off gears in combination with sliding gear in head giving two quick changes in speed. Use of two-speed motor makes four speed changes available



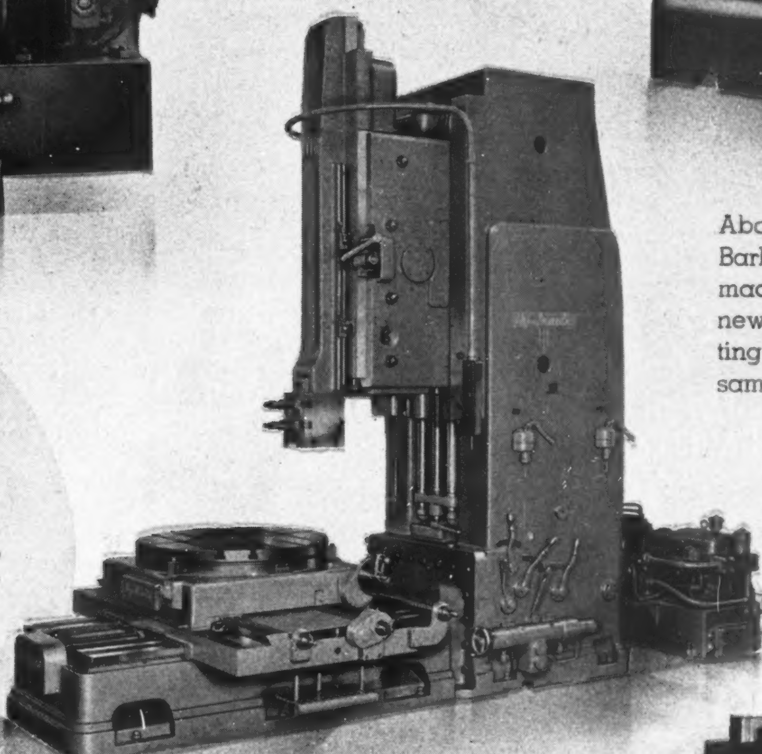
Right above—Model 1L saddle type turret lathe by Gisholt offers excellence in styling plus ready accessibility of all adjustments, such as those for clutches, main drive motor, V-belt, spindle brake, etc. Machine also features a hydraulic spindle-speed selector and single-dial feed change

F THE MONTH

1947 Machine Tool Show, Dodge-Chicago plant, September 17 through 26

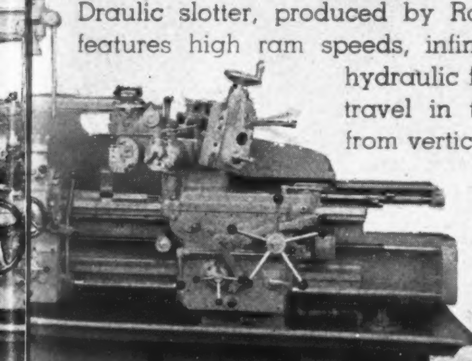
Left, below—Shaper by The Smith & Mills Co. incorporates slotless-type ram which can be positioned while in motion or at rest. Automatic pressure lubrication is used throughout and controls are centralized to provide quick access for machine operator

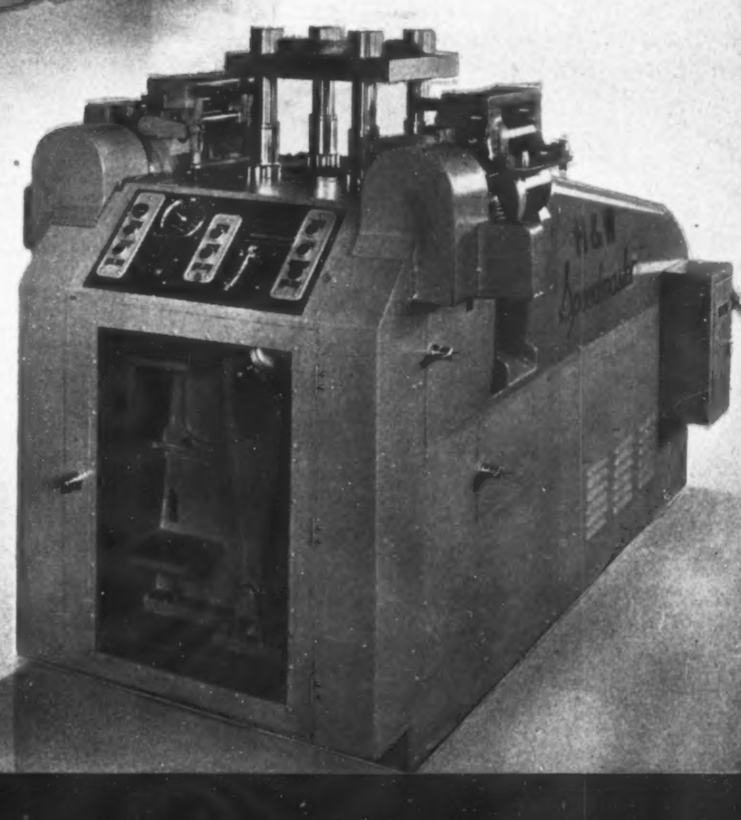
Above—Automatic Hob Shifter on Barber-Colman's Type V hobbing machine automatically shifts hob to new cutting position after each cutting cycle. Shifter is actuated by same hydraulic oil that powers the machine cutting cycle



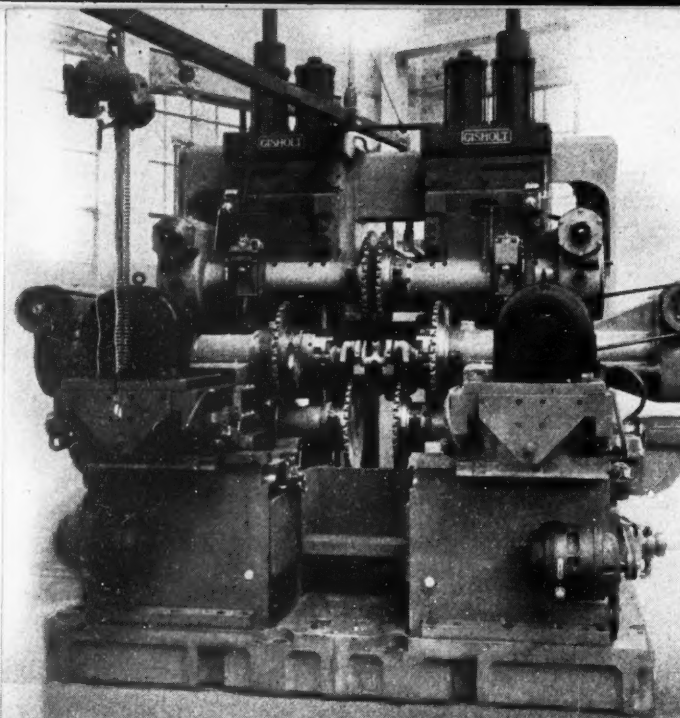
MORE GOODS FOR MORE PEOPLE • AT LOWER COST • MT

Right, above—Built in 36 and 48-inch stroke sizes, the Hy-Draulic slotter, produced by Rockford Machine Tool Co., features high ram speeds, infinite speed adjustment and hydraulic feeds. Ram may be set for travel in tilted plane at any angle from vertical to 10 degrees off vertical

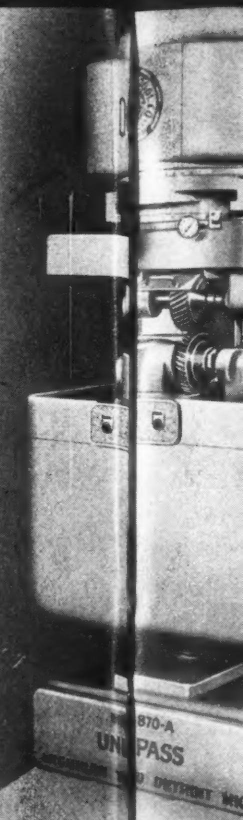




Right — Patented counter-balancing mechanism in 25-ton Speedmaster dieing machine makes possible top-speed operation without bolting machine to floor. Machine drive is from variable-speed transmission through pneumatically actuated friction clutch which is electrically controlled from panel. Mfr: The Henry and Wright Mfg. Co.

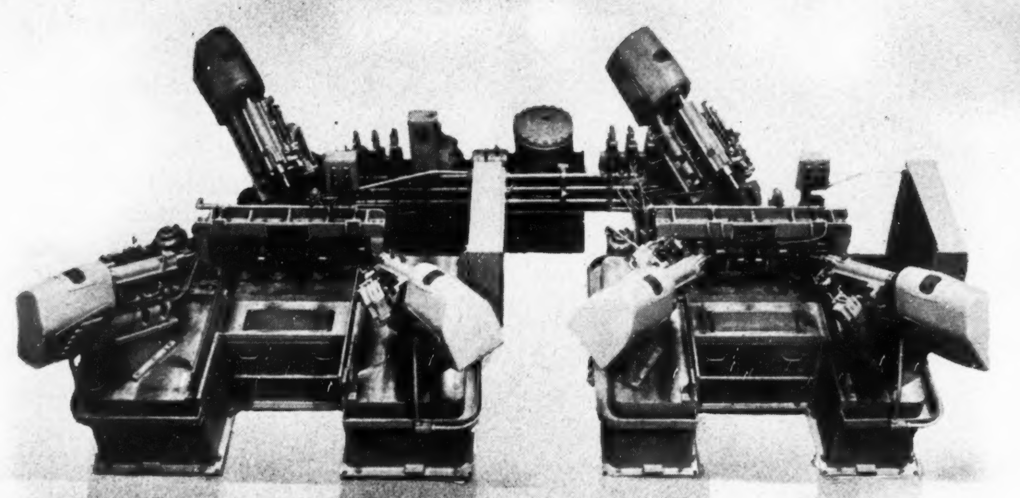


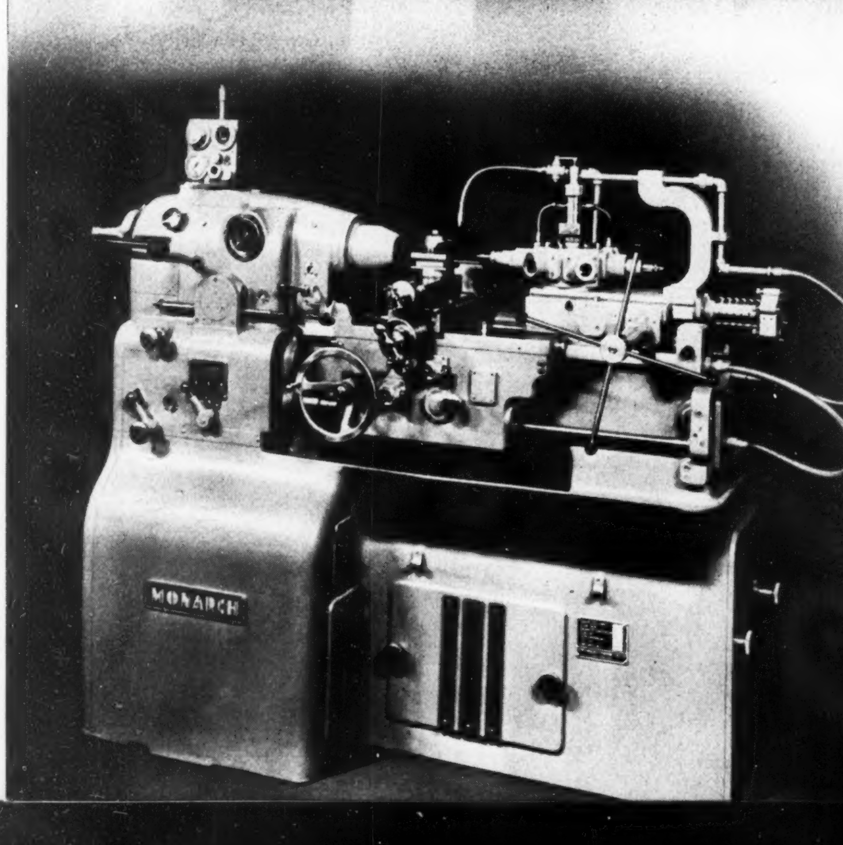
Left—Gisholt Machine company's crankshaft turn-miller simultaneously turn mills all crankpins, and faces adjacent cheeks and counterweights on a crankshaft to a finish ready for grinding. Headstock cams hydraulically control movements of milling cutters, each of which is driven by 25-hp motor



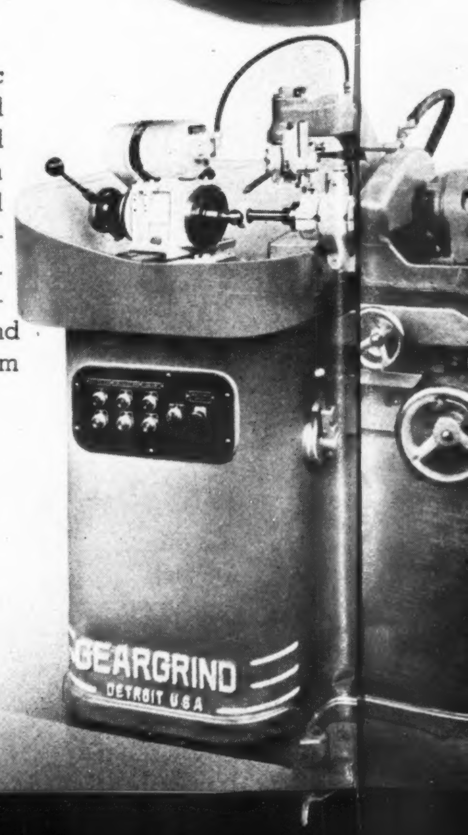
Right—Michigan Tool company's Model 870-A Underpass crossed-axis rotary gear finisher permits gear finishing by the underpass, transverse and traverpass methods. Speed reducer in head is Cone-Drive geared 30 to 1 for the slide movement

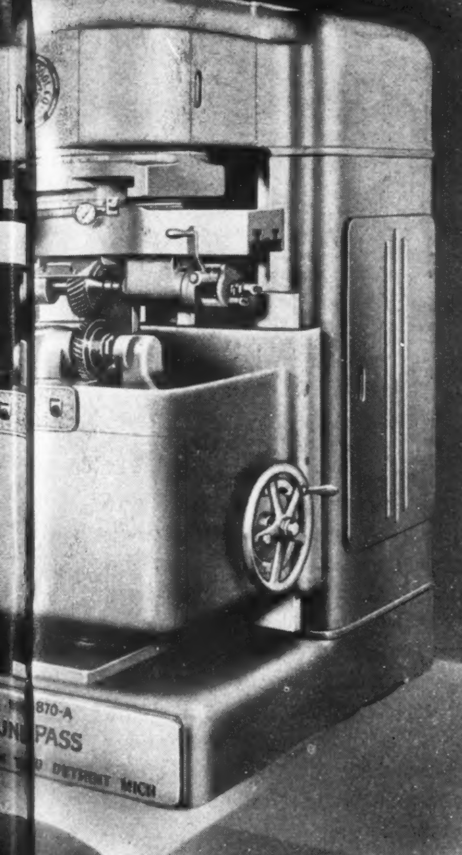
Below—Special crankshaft drilling machine by The Avey Drilling Machine Co. consists of two bases, each mounting three Aveydraulic deephole drilling units, all six of which are driven by a single Vickers pump (at rear of machine). Drilling units incorporate controls to automatically withdraw drills for chip clearance





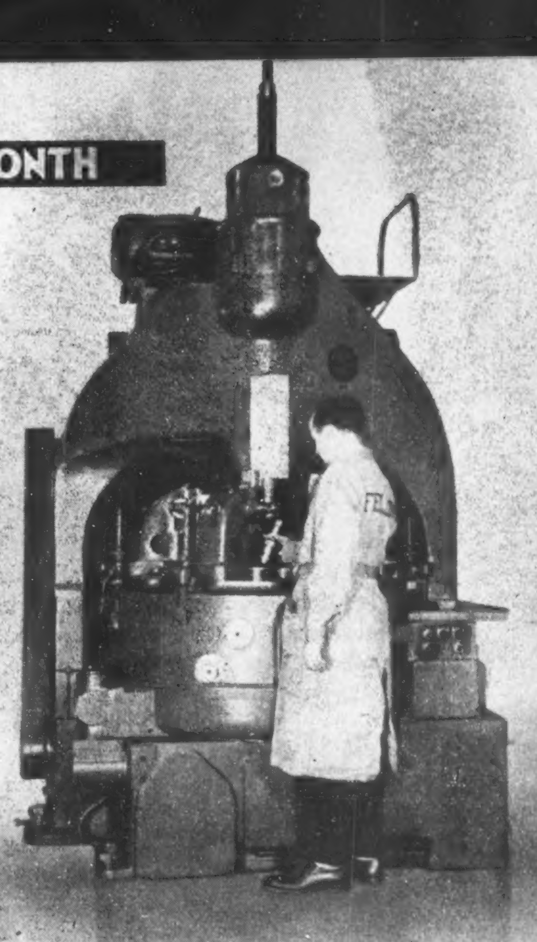
Left — Automatic electric system for selecting and controlling speeds and feeds is incorporated in Monarch Machine Tool company's Speedi-Matic hand screw machine. Stepless range of spindle speeds, forward and reverse, is 50 to 5000 rpm



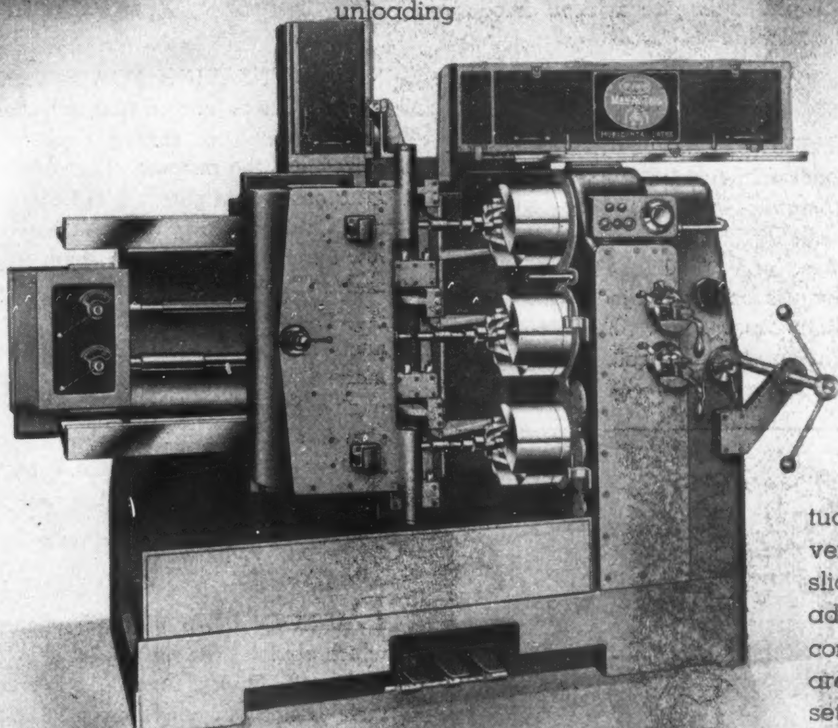


DESIGNS OF THE MONTH

Right—Planetary gear shaper employs large gap-type cutter around which the work planets. Cutter reciprocates but does not rotate. Work is held on individual work-spindles carried in rotating turret. Mfr: The Fellows Gear Shaper Co.

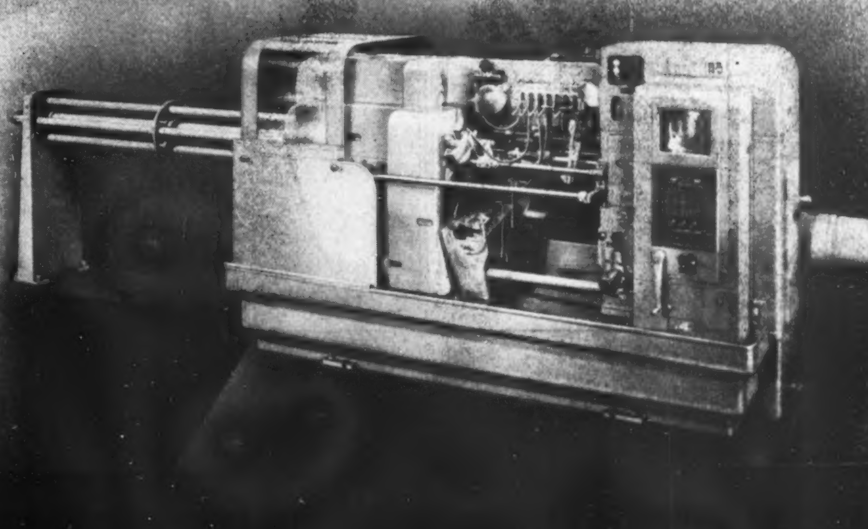


Below—In Bullard's Model 30 Man-Au-Trol Horizontal Lathe, tools are mounted in vertical plane on slide to rear of the vertical plane in which the three spindles operate. Sixteen feeds from 0.0003 to 0.0156, with 40 speeds from 50 to 1200 rpm are provided along with semi-automatic loading and unloading



Below—Five-spindle bar and chucking automatic employs quadrant linkage for cross and longitudinal feeds instead of conventional cams; four cross-slides, each with micrometer adjustment. Single spindle control and indexing cutout are employed to expedite setting up of job. Mfr: The Warner & Swasey Co.

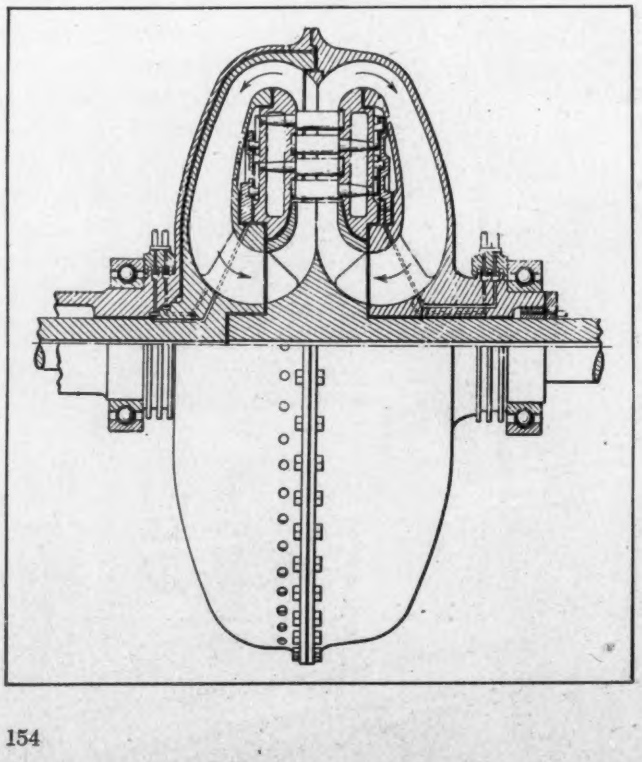
Left—Developed for grinding spherical, conical and cylindrical surfaces of small parts, this universal oscillating grinder by The Gear Grinding Machine Co. employs work table which can be oscillated by hand through 180 degrees or power oscillated through 90 degrees



Noteworthy Patents

COMPLETE RELEASE of all hydraulic fluid from both lines of any branch in a system is accomplished automatically by a novel valve assigned to Adel Precision Products Corp. by Arthur A. Bell under patent 2,417,231. Particularly intended for hydraulic motion transmitting systems of the closed-circuit type, the valve automatically frees the master unit completely to allow manual operation without opposition in the event either supply line of the system is ruptured. In the event of a broken line, the greater pressure in the remaining line often would, of course, create an undesirable movement of the slave unit. However, the valve covered in this patent, automatically on a drop in pressure, permits the fluid of this line to flow into the ruptured line to achieve freedom necessary for manual control.

LARGE AND VARIABLE SPEED CHANGES are accommodated by the hydraulic turbine type torque converter and fluid coupling, detailed in patent 2,416,948, while delivering substantially constant power. Assigned to Northrup Aircraft, Inc. by V. H. Pavlecka, the device is particularly suited for use on gas-turbine powered aircraft using counter-rotating propellers. Fluid circulates through the housing in substantially radial planes and rows of reaction turbine blades, attached alternately to the turbine wheels, are pivoted to allow variation of their angle of attack during operation. An arcuate piston and piston chamber, which rotates with each turbine wheel, is connected through linkages to the blades so that by varying the pressure within the piston chamber the blade angles may be varied to permit the turbine to operate at increasing speed with increasing altitude and simultaneously permit the propellers to operate at decreasing speed. Efficiency is nearly constant over the entire speed range and is equal to or better than that of conventional systems, while weight is considerably less.



COMPENSATION FOR EXPANSION and contraction of fluid due to temperature or leakage as well as protection against pinch or similar damage to the synthetic diaphragm is the purpose of an unusual pneumatic accumulator covered in patent 2,417,256. Assigned to Adel Precision Products Corp. by A. E. Kremiller, the unit utilizes a low-temperature grease cushion to support the diaphragm and maintain pressure between it and a floating dual piston. Each of the two equal chambers of the unit connects to one line of the system, specifically the closed, manually operated and remote control type for operating engine throttles, control levers, etc. Included in the design is an indicator, magnetically operated from the iron floating piston, to show the extent of the compensating action being affected by the unit.

DIRECT-CURRENT self-synchronous servo system which obviates the difficulties previously encountered with such units having brushes, commutators and sliding contacts is outlined in patent 2,415,985 assigned to Bendix Aviation Corp. by P. F. Bechberger and W. A. Reichel. Brushless, this direct-current transmitter achieves the necessary sensitivity for transmission of accurate signals by employing conductor elements of bismuth whose electrical resistance varies in the presence of a magnetic field. Currents flowing through each of the stator resistors, with normal conditions, are all equal. Under influence of movement of the permanent-magnet rotor, however, the resistor values change, and likewise change the currents flowing to the receiver windings in the same amount thus exerting torque upon the receiver rotor until it moves into exact agreement with the position of the transmitter rotor.

Nomograph Simplifies Planetary Gear Calculations

By Alexander Cowie
Foote Bros. Gear & Machine Corp.
Chicago

IN A SIMPLE planetary or epicyclic gear train, consisting of internal gear, sun gear and planet arm, the speed relations between any two of the elements when the third element is stationary are well known. When the third element rotates (e.g., in variable-speed drives) the method of determining the speed relations is not so well known, but may readily be found from the chart on the following page. It can be shown that

$$A=\frac{S}{R+1}+\frac{R}{R+1}G \quad (1)$$

$$S=(R+1)A-RG \quad (2)$$

$$G=\frac{R+1}{R}A-\frac{S}{R} \quad (3)$$

where A = speed of planet arm, S = speed of sun gear, G = speed of internal gear, all in rpm, and R = gear ratio = ratio of number of teeth in internal gear to that in sun gear. If $A = 0$, Equation 2 gives $S = -RG$, which is the obvious relation for a simple gear train. If $G = 0$ in Equation 2, $S = (R + 1)A$, which is the well-known relation for a planetary train with the internal gear fixed. When $S = 0$ in Equation 1 $A = RG/(R + 1)$, which applies to a planetary train with a fixed sun gear.

In order to construct a nomographic chart for the graphical solution of the foregoing equations, the S and G scales (dimensionally equal) are first drawn parallel and at a distance apart equal to the full width of the chart. The A scale is located between the S and G scales, the exact position being determined by the gear ratio R. Thus, when $A = 0$ Equation 2 gives $S = -RG$, and if $R = 2$, for example, $S = -2G$. Selecting points on both the S and G scales having this relation (e.g., $S = 10$, $G = -5$) and joining them with a straight line, this line will cut the $0-0$ line at the point where the A scale is located for this particular gear ratio. That the dimensions of the A scale will be the same as both the S and G scales can be verified by letting $G = 0$ in Equation 1. Then $A = S/3$ and a line from 0 on the G scale to 3 on the S scale will pass through 1 on the A scale. This point is the same distance above the $0-0$ base line as 1 on both the S and G scales. To locate the A scale for any gear ratio R, select points on the S and G scales such that $S = -RG$ and connect them with a straight line intersecting the $0-0$ base line.

The chart is useful for the solution of problems of the following types:

1. Knowing the gear ratio and the speed and direction of rotation of any two of the elements, to determine the speed and direction of rotation of the third element
2. Knowing the gear ratio and the speed and direction of rotation of one element (say S), to determine the speed and direction of rotation required for the second element (say G) in order that the third element (A) may be made to satisfy certain speed requirements
3. Knowing the speed and direction of rotation of any two elements (say S and G) to determine the effect of variations in the gear ratio on the required speed of the third element.

Problems of each type are illustrated by the following examples. On the chart, each of the scales is numbered from -10 to $+10$. For speeds numerically greater than 10, the given speeds are first reduced so that the highest speed is within the scale range by dividing by 10, 100, 1000, etc.

Example 1 (Type 1): Given $S = +3000$ rpm, $A = -20$ rpm, $R = 3$, to find G. Dividing by 1000, $S = +3$, $A = -0.02$. From $+3$ on the S scale draw a line to -0.02 on the A scale for $R = 3$. This line produced cuts the G scale at -1 plus. Then $G = -1000$ plus, the correct value, from formula, being -1027. Thus even when the speeds are considerably different in magnitude, the chart gives reasonably accurate results.

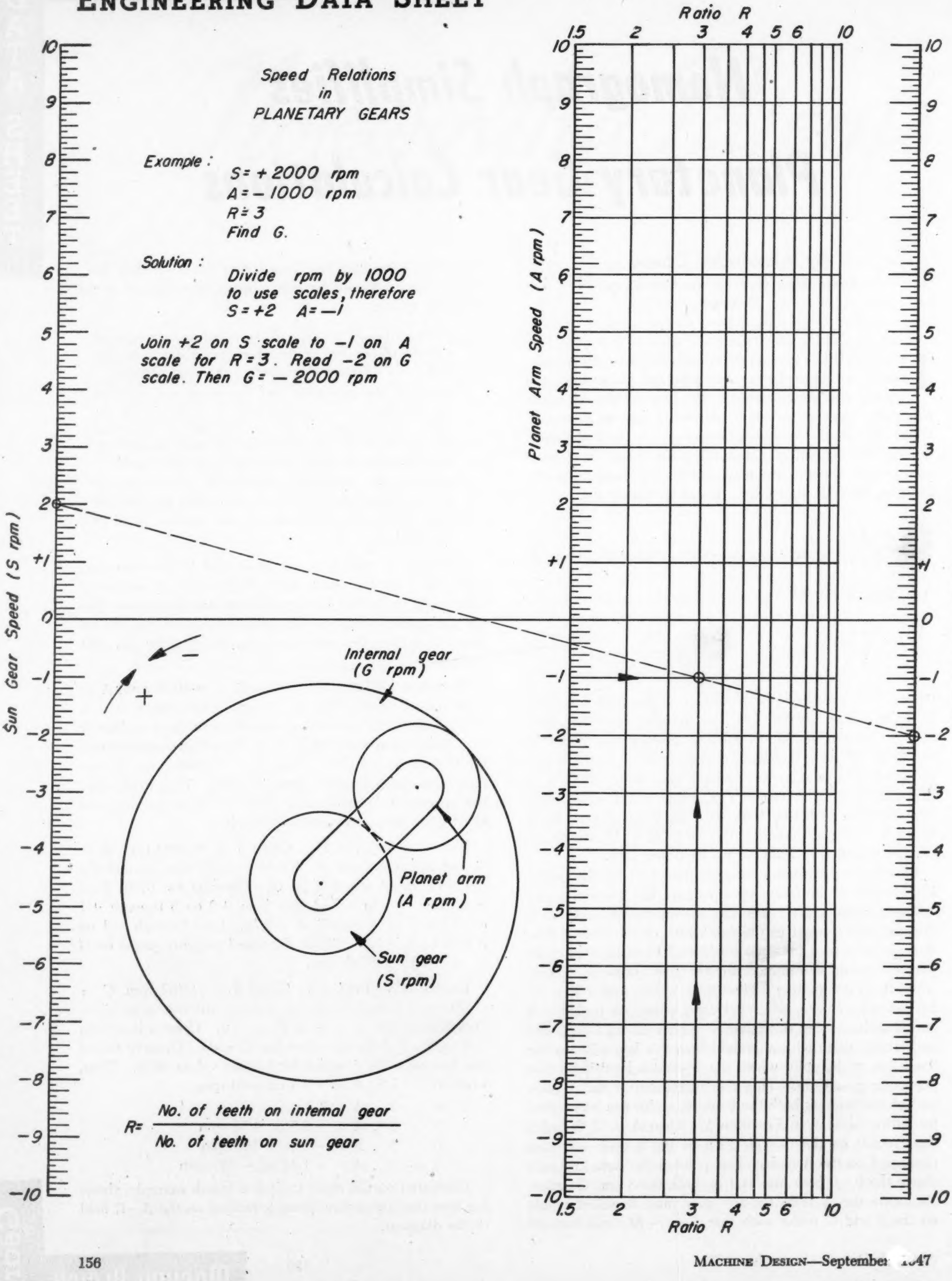
Example 2 (Type 2): Given $S = +2000$ rpm, $R = 4$, and A varies from $+1000$ to -1000 rpm, to find the range of speed required on G. Dividing by 1000, $S = +2$, $A = +1$ to -1. A line from $+2$ on S through $+1$ on A for $R = 4$ cuts G at $+0.75$. Line through -1 on A cuts G at -1.75. Then the speed range required on G $= +750$ to -1750 rpm.

Example 3 (Type 3): Given $S = +400$ rpm, $C = -200$ rpm, to find the speed of A for different gear ratios. Dividing by 100, $S = +4$, $G = -2$. Draw a line from $+4$ on the S scale to -2 on the G scale. Observe where this line cuts the A scales for various values of R. Thus,

when $R = 1.5$, $A = +0.4$ or $+40$ rpm
$R = 2$, $A = 0$
$R = 3$, $A = -0.5$ or -50 rpm
$R = 5$, $A = -1$ or -100 rpm
$R = 10$, $A = -1.45$ or -145 rpm

Illustrated on the chart itself is a fourth example, showing how the appropriate point is located on the $A-R$ field of the diagram.

ENGINEERING DATA SHEET



MACHINE DESIGN'S MATERIALS WORK SHEET

FILING NUMBER
1.00

Standard Steels

Wrought AISI Types

PART I

KEY FACTS ABOUT ALL STEELS

Tensile strength always is approximately 500 times the Brinell hardness number, irrespective of composition or heat treatment

Modulus of elasticity of all steels and regardless of hardness is for all practical purposes the same—about 30,000,000 psi

All steels of any given type, when full hardened and tempered, have substantially identical relationship between Brinell hardness, yield point, tensile strength, reduction of area, and elongation

In the fully hardened and tempered state, hardness is always dependent on carbon content, *not* on the quantity or number of alloys used in the composition

Depth to which all steels will harden depends on carbon content *and* alloying constituents

Primary difference between the straight-carbon and the alloy steels lies in the depth to which they will harden. Carbon steels are shallow hardening. All alloy steels harden more deeply than do carbon steels; how much more deeply depends on alloy constituency

End-quench hardenability bands reveal: Relationship between cooling rates used in quenching a given steel and hardnesses resulting therefrom throughout the structure of shapes the cooling rates of which are known. (From these hardness data and standard charted curves, the tensile strength, yield point, reduction of area and elongation of the various shapes can be approximated)

End-quench hardenability bands do not reveal: Corrosion resistance, machinability, weldability, forgeability, temperature resistance (high or low), wear resistance or distortion in heat treatment.

STEELS COVERED

(AISI NUMBERS)

C 1005	C 1036	C 1071	C 1115	2317	4037	4620	6120	8735
C 1006	C 1038	C 1074	C 1116	2330	4042	E 4620	6145	8740
C 1008	C 1039	C 1075	C 1117	2335	4047	X 4620	E 6150	8742
C 1010	C 1040	C 1078	C 1118	2340	4053	4621	6152	8745
C 1012	C 1041	C 1080	C 1119	2345	4063	4640	8615	8747
C 1013	C 1042	C 1084	C 1120	E 2512	4068	E 4640	8617	8750
C 1015	C 1043	C 1085	C 1125	2515	4130	4812	8620	9255
C 1016	C 1045	C 1090	C 1126	E 2517	E 4132	4815	8622	9260
C 1017	C 1046	C 1095	C 1137	3115	E 4135	4817	8625	9261
C 1018	C 1050	B 1006	C 1138	3120	4137	4820	8627	9262
C 1019	C 1051	B 1010	C 1140	3130	E 4137	5045	8630	E 9310
C 1020	C 1052	D 1049	C 1141	3135	4140	5046	8632	E 9315
C 1021	C 1054	D 1054	C 1144	3140	4142	5120	8635	E 9317
C 1022	C 1055	D 1059	C 1145	3141	4145	5130	8637	9437
C 1024	C 1057	D 1064	C 114[illegible]	3145	4147	5132	8640	9440
C 1024	C 1059	D 1069	C 1151	3150	4150	5135	8641	9442
C 1025	C 1060	D 1075	B 1111	E 3310	4317	5140	8642	9445
C 1026	C 1061	C 1106	B 1112	E 3316	4320	5145	8645	9747
C 1027	C 1062	C 1108	B 1113	4017	E 4337	5147	8647	9763
C 1028	C 1064	C 1109	1320	4023	E 4340	5150	8650	9840
C 1029	C 1065	C 1110	1321	4024	4340	5152	8653	9845
C 1030	C 1066	C 1111	1330	4027	4608	E 50100	8655	9850
C 1033	C 1069	C 1113	1335	4028	4615	E 51100	8660	
C 1034	C 1070	C 1114	1340	4032	E 4617	E 52100	8720	
C 1035								

Note: Last two digits of all numbers indicate the approximate carbon content of the steel (for example, C 1026 has a carbon content of about 0.26 per cent). In conjunction with the curves of *Fig.* 6, this data may be used to determine the hardness obtainable in a given steel.

CHARACTERISTICS

It has been definitely established that all steels, irrespective of their chemical compositions, if through-hardened and tempered to identical hardness, will have, for all practical purposes, the same tensile strength, yield strength, elongation and reduction of area. This being the case, why use alloy steels at all? The answer lies in the ability of alloy steels to quench-harden to greater depths than carbon steels. That is to say, in thin sections such as 3/16-inch, carbon steel may be quenched

MACHINE DESIGN is pleased to acknowledge the collaboration of the following organizations in this presentation: American Iron and Steel Institute; Battelle Memorial Institute; Bethlehem Steel Co.; Bliss & Laughlin, Inc.; Carnegie-Illinois Steel Corp.; General Motors Corp., Research Laboratories Division; Republic Steel Corp.; Joseph T. Ryerson & Son, Inc.; and Society of Automotive Engineers, Inc.

to fully as high hardness and strength as any alloy steel in the same size. But, in larger sections, such as 1-inch diameter, carbon steels cannot be hardened beyond a depth of perhaps 3/16-inch, so that the core remains unhardened and therefore not very strong. On the other hand, many alloy steels can be through-hardened in 1-inch sections and some of them in considerably heavier sections. Thus it is not higher hardness, but *greater depth* of hardening which accounts for the higher strength of pieces of substantial size when made of an alloy steel rather than a carbon steel.

The standard steels may be divided into two classes comprising: (1) Carburizing steels, which contain up to about 0.25 per cent carbon, and (2) oil and water-hardening steels, which contain from about 0.25 to 0.50 per cent carbon. In general, the carburizing steels are used where a hard, wear-resistant surface is required together with maximum toughness and resistance to shock. The oil and water-hardening steels frequently are used with machining performed after heat treatment to provide smooth, bright, scale-free surfaces, with accuracy of dimensions in the finished parts.

FATIGUE STRENGTH

As is generally recognized, failures of machine parts in service are almost always attributable to fatigue or wear. Both these sources of failure are surface phenomena, being dependent on surface smoothness and hardness. Under ideal conditions (mirror surfaces and no stress raisers) fatigue strength averages roughly 50 per cent of tensile strength. Naturally, inasmuch as tensile strength increases proportionately with hardness, fatigue strength (under ideal conditions) is highest for steels which are highly hardened. However, since sensitivity to stress raisers increases with hardness, and since complete absence of stress raisers is never attained, hardness specifications for parts subject to high fatigue loading must be a compromise. The curves of *Fig.* 1 show endurance limit (fatigue strength) as related to tensile strength for parts having various surface conditions. Endurance limit can be enhanced appreciably by burnishing part surfaces with pressure rollers or by shot peening.

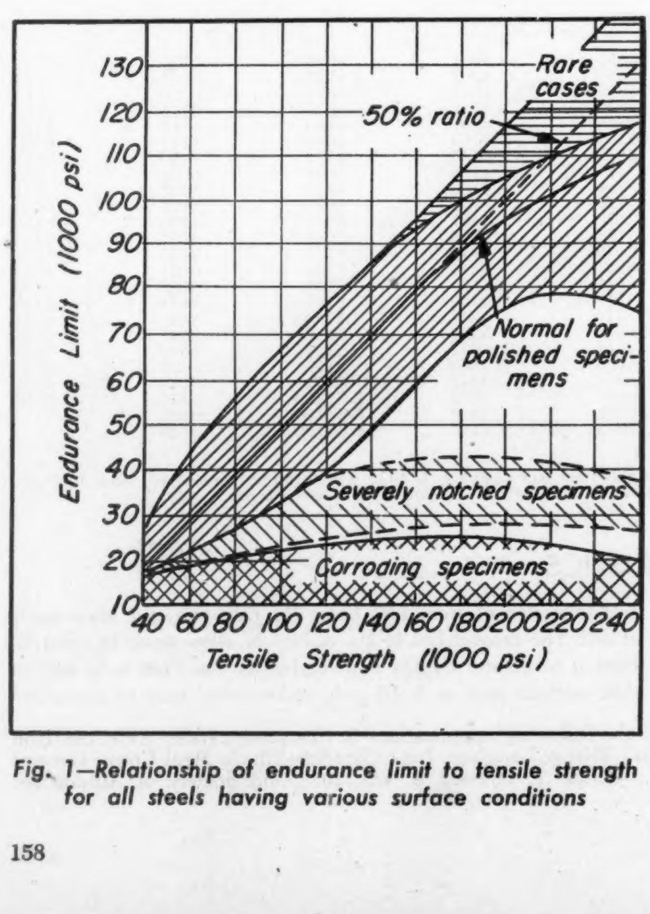


Fig. 1—Relationship of endurance limit to tensile strength for all steels having various surface conditions

IMPACT STRENGTH

While impact values (Charpy and Izod) for various steels are listed in numerous handbooks and other literature, they are not directly usable in terms of foot-pounds because impact strength, or shock resistance, varies with size of section. Such values are merely general criteria for comparing the shock resistance of various steels. All rolled or drawn steels have greater impact strength in the longitudinal direction—in which the standard tests are made—than in the transverse direction. Thus the standard impact tests conducted on notched specimens give only a rough indication of shock strength—nothing more. In general, fine-grain steels have higher impact strength than coarse-grain steels. Experience shows that when alloy steel parts require high shock resistance, it is wise not to temper them at temperatures between 450 and 700 F because impact strength drops off in this range. Of course ductility is highest when tempering temperatures above 700 F, rather than below 450 F are employed.

WEAR RESISTANCE

This is almost entirely a matter of surface hardness. The harder the surface the greater its resistance to wear. Since the hardness of all steels is dependent on carbon content, where good wear resistance is required the surface layer of the part must have high carbon content. Depending on requirements of the part other than wear resistance, high hardness may be obtained in a low-carbon steel (either straight-carbon or alloy type) by case hardening, or in a high-carbon steel (either straight-carbon or alloy type) by quenching and tempering. Thus, for wear resistance alone, any steel can, by appropriate treatment, be made sufficiently hard at its surface to serve the purpose. Selection, therefore, must be based on other factors such as strength requirements, corrosion resistance, high or low temperature properties, etc., depending on the application.

PROPERTIES OF STEELS AS HOT-ROLLED AND COLD-DRAWN

A wide variety of machine parts do not require the high strength available from steels in the case-hardened or quenched and tempered conditions. Many screws, bolts, nuts, gears, shafts, pins, links, structural members, cover plates, mounting brackets, studs, etc., fall into this category. For such parts, the plain carbon steels, the bessemer screw steels and the carbon-manganese steels in the hot-rolled or cold-drawn condition are adequate. Average properties of the standard steels in these conditions are listed in Table I. The values are offered only as a general guide to assist in selection and should not be used as a basis for specification.

Hot-rolled bars are available annealed, stress-relief annealed, machine cut or machine straightened, and surfaces may be specified "as-rolled" or "pickled." Pickling, of course, removes surface scale. Generally, hot-rolled bars are used for parts whose surface appearance and accuracy of size and section are not important, and where either little or no machining is required. Hot-rolled bars usually are not suitable for screw-

TABLE I—AVERAGE PROPERTIES, HOT-ROLLED AND COLD-DRAWN*

AISI No.	Condition	Tensile Strength (psi)	Yield Point (psi)	Elong. (per cent in 2 in.)	Red. of area (per cent)	Hardness Brinell	Hardness Rock-well C
C 1010	Natural hot-rolled	51,000	29,000	38	70	101	..
	Cold-drawn	56,000	33,000	35	65	113	..
C 1015	Natural hot-rolled	65,000	40,000	32	65	137	..
	Cold-drawn	67,000	43,000	30	62	143	..
C 1020	Natural hot-rolled	67,000	45,000	32	65	137	..
	Cold-drawn	69,000	48,000	30	63	143	..
C 1022	Natural hot-rolled	69,000	47,000	30	58	143	..
	Cold-drawn	78,000	53,000	23	54	163	..
C 1030	Natural hot-rolled	75,000	46,000	29	58	156	..
	Cold-drawn	85,000	72,000	20	47	179	8
C 1035	Natural hot-rolled	88,000	55,000	30	56	179	10
	Cold-drawn	92,000	59,000	25	50	200	12
C 1040	Natural hot-rolled	93,000	58,000	27	52	190	9
	Cold-drawn	100,000	64,000	22	46	221	19
C 1045	Natural hot-rolled	99,000	60,000	24	47	200	12
	Cold-drawn	110,000	69,000	19	41	235	21
C 1055	Hot-rolled, annealed	95,000	59,000	25	52	197	14
C 1064	Hot-rolled, annealed	100,000	60,000	22	50	212	17
C 1080	Hot-rolled, annealed	103,000	62,000	22	48	217	18
C 1095	Hot-rolled, annealed	106,000	60,000	23	47	201	12
B 1111	Natural hot-rolled	67,000	40,000	27	47	140	..
B 1112	Cold-drawn	80,000	62,500	16	43	170	6
B 1113	Cold-drawn	83,000	73,000	15	45	180	8
C 1115	Cold-drawn	91,000	77,000	13	40	187	9
C 1117	Natural hot-rolled	71,000	45,000	28	52	135	..
	Cold-drawn	82,000	63,000	18	44	162	..
C 1118	Natural hot-rolled	76,000	49,000	24	50	153	..
	Cold-drawn	89,000	69,000	16	40	179	8
C 1132	Natural hot-rolled	90,000	56,000	22	40	179	8
	Cold-drawn	100,000	75,000	16	35	207	16
C 1137	Natural hot-rolled	92,000	60,000	20	35	185	9
	Cold-drawn	105,000	80,000	15	30	212	15
A 2317	Natural hot-rolled	85,000	56,000	29	60	163	..
	Cold-drawn	95,000	75,000	25	58	197	12
A 2330	Natural hot-rolled	98,000	65,000	25	50	207	16
	Cold-drawn	110,000	90,000	17	47	235	22
A 2340	Natural hot-rolled	110,000	80,000	22	47	225	19
	Annealed & cold drawn	115,000	90,000	21	48	235	21
A 2515	Natural hot-rolled	92,000	69,000	27	67	179	8
	Cold-drawn	103,000	75,000	24	62	207	16
A 3115	Natural hot-rolled	75,000	60,000	30	65	151	..
	Cold-drawn	95,000	70,000	20	53	201	12
A 3130	Natural hot-rolled	100,000	72,000	24	55	212	15
	Cold-drawn	105,000	85,000	18	48	223	19
A 3135	Hot-rolled, annealed	96,000	64,000	26	56	195	12
	Annealed & cold-drawn	115,000	98,000	17	45	248	24
A 3141	Hot-rolled, annealed	100,000	68,000	24	54	207	16
	Annealed & cold-drawn	118,000	100,000	17	44	248	24
A 3145	Hot-rolled, annealed	104,000	73,000	19	51	229	21
	Annealed & cold-drawn	123,000	95,000	14	33	269	27
A 3240	Hot-rolled, annealed	107,000	75,000	23	57	197	13
A 4119	Natural hot-rolled	91,000	52,000	28	62	179	..
	Cold-drawn	97,000	63,000	21	51	207	..
A 4130	Hot-rolled, annealed	89,000	60,000	32	65	179	7
	Annealed & cold-drawn	112,000	78,000	18	47	241	23
E 4137	Hot-rolled, annealed	90,000	63,000	27	58	187	12
	Annealed & cold-drawn	114,000	90,000	18	50	241	23
E 4150	Hot-rolled, annealed	105,000	71,000	21	54	220	20
	Annealed & cold-drawn	124,000	100,000	16	48	269	27
A 4320	Natural hot-rolled	87,000	59,000	30	60	179	10
	Cold-drawn	99,000	65,000	23	54	207	16
E 4337	Hot-rolled, annealed	115,000	95,000	18	45	235	21
A 4615	Natural hot-rolled	82,000	55,000	30	61	167	4
	Cold-drawn	98,000	70,000	18	55	203	14
A 4640	Hot-rolled, annealed	100,000	87,000	21	50	201	12
	Annealed & cold-drawn	126,000	97,000	14	39	269	27
A 4815	Natural hot-rolled	105,000	73,000	24	58	212	15
	Cold-drawn	110,000	78,000	23	55	217	17
A 5120	Natural hot-rolled	73,000	55,000	32	67	143	..
	Cold-drawn	82,000	60,000	25	58	163	6
A 5150	Hot-rolled, annealed	103,000	68,000	22	57	201	12
	Cold-drawn	115,000	77,000	18	52	248	24
E 52100	Hot-rolled, annealed	109,000	80,000	25	57	235	22
E 6150	Hot-rolled, annealed	103,000	70,000	27	51	217	18
	Annealed & cold-drawn	118,000	94,000	20	43	255	25
A 9255	Hot-rolled	135,000	90,000	19	40	269	27
A 9260	Hot-rolled, annealed	142,000	92,000	18	38	302	31

Note: Standard steels with AISI numbers close to those listed will have average properties approximating those of the closely similar steel.
*From *Metals and Alloys Data Book*, Pages 29-34, 1943, Reinhold Publishing Corp.

machine work because they generally require that special collets be used due to stock size and shape variations.

Cold-drawn bars are produced by cold-drawing scale-free hot-rolled bars through suitable hardened dies, decreases in section size being effected for each pass through the dies. Cold-drawn bars are available as-drawn to standard and special shapes, turned and polished, turned and ground, and cold-drawn and ground. Cold-drawing produces substantially defect-free, smooth, bright-surfaced bars of accurate size and concentricity, improved machinability, and heightened tensile, yield, fatigue and hardness values. Increases in tensile strength due to cold-drawing may range from 15 to 60 per cent, and increases in yield strength may range from 50 to 150 per cent, depending on the steel, its hot-rolled condition, and the degree of size reduction effected during cold drawing. Along with increases in tensile and yield strength, there will, of course, be proportionate increases in hardness and decreases in elongation and reduction of area. Generally, as cold-drawn steel ages, its tensile and yield strengths improve slightly and its elongation and reduction of area increase appreciably.

PROPERTIES OF STEELS WHEN HARDENED AND TEMPERED

Inasmuch as tensile strength, yield strength and reduction of area are dependent upon hardness, regardless, of the composition of a steel, data on these properties for all standard steels may most conveniently be presented in charts. These data*, *Figs.* 2, 3 and 4, apply to all steels having carbon contents from 0.30 to 0.50 per cent in AISI series 1000, 1100, 1300, 2300, 3100, 3200, 4100, 4300, 4600, 5100, and 6100.

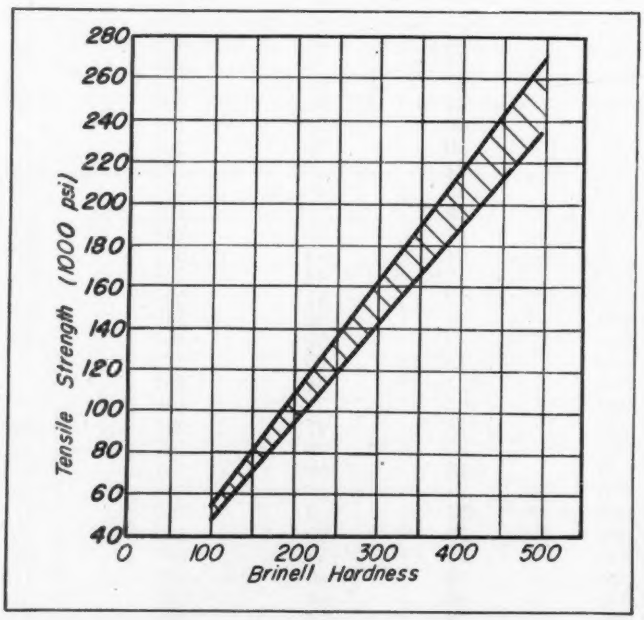


Fig. 2—Relationship of tensile strength to hardness. Tensile strength averages about 500 times Brinell number

Tensile Strength Chart: The fixed relationship between hardness and tensile strength is shown by the narrow curve-band of *Fig.* 2. This relationship applies to steels in the hardened and tempered, as-rolled, annealed and normalized conditions.

* SAE Handbook, 1946.

Yield Strength Chart: The curve-band of *Fig.* 3 shows the fixed relationship of yield-strength range and hardness. The values apply to steels as quenched and tempered.

Reduction of Area Chart: Fixed relationship between reduction-of-area range and hardness is shown in *Fig.* 4. It will be seen that for a given hardness, reduction of area is higher

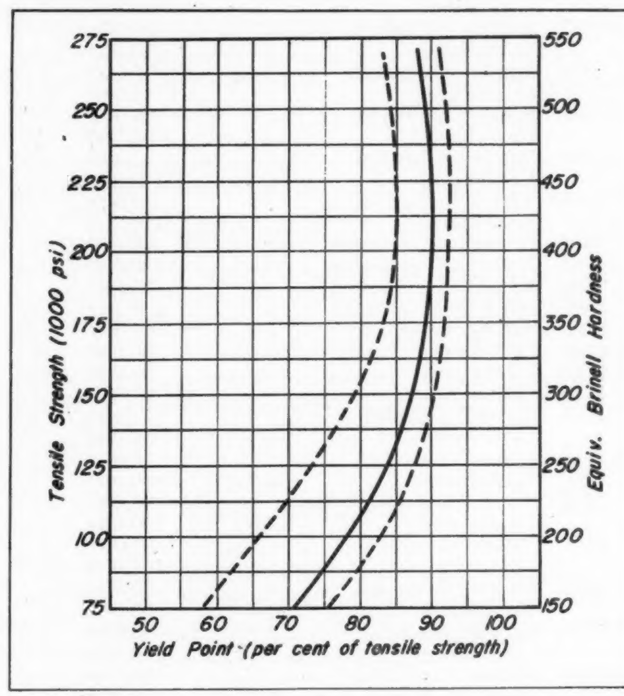


Fig. 3—Above—Relationship of yield point and tensile strength for quenched and tempered steels. Solid curve shows normal expectancy. Dotted lines show range

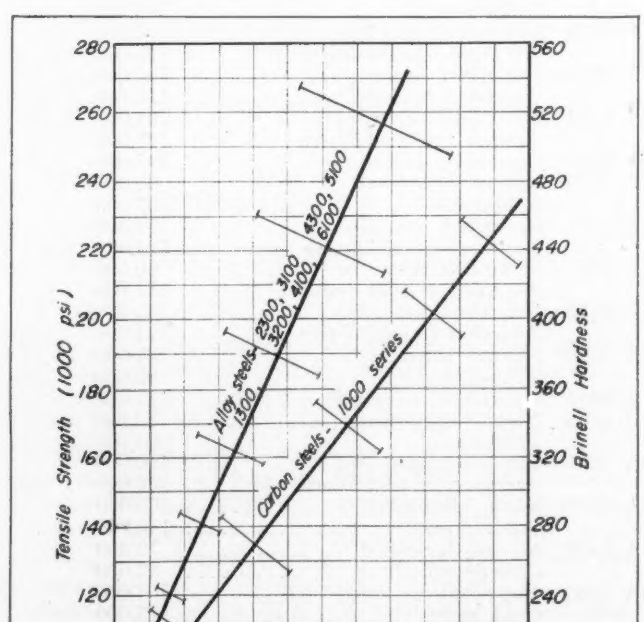


Fig. 4—Relationship of reduction of area to hardness

for alloy steels than for plain carbon steels. This probably is merely because the plain carbon steel in the size tested did not harden clear through.

TEMPERED-HARDNESS TO STRENGTH RELATIONSHIP

Steels of comparable carbon content, regardless of alloy content, when fully hardened and then tempered to the same hardness, will have substantially the same tensile and yield strengths. This relationship is indicated by the curves of *Fig.* 5. These data apply to steels having carbon content between 0.30 and 0.50 per cent and of the AISI series 1000, 1100, 1300, 2300, 3100, 3200, 4100, 4300, 4600, 5100, and 6100.

HARDNESS OBTAINABLE

Magnitude of hardness obtainable in all steels is dependent on carbon content, not on the quantity or number of alloys used in the steel. The relationship between carbon content and hardness obtainable is shown by the curves of *Fig.* 6.

HARDENABILITY

A steel might have a carbon content sufficient to permit requisite hardness and yet not harden fully if the rate at which it is cooled during quenching is not fast enough. When a piece of hot steel is thrust into a quenching bath of water, brine or oil, the rate at which it cools is, obviously, fastest near and at its surface and slowest at its center. Since straight carbon steels require a faster rate of cooling to develop full hardness than do alloy steels, the depth to which they will harden upon quenching will not be as great as for the alloy steels. In other words, they do not possess as high a degree of *hardenability* as the alloy steels. While all alloy steels will harden to a greater depth than plain carbon steels, their hardenability will vary, depending on their alloy constituency.

HOW HARDENABILITY IS DETERMINED

Determination of what hardnesses will exist throughout a section of a given alloy steel upon quenching is effected by means of the Jominy end-quench hardenability test. In this test, a sample piece of steel 1-inch in diameter by 4 inches long is heated to the proper quenching temperature and placed in a quenching fixture, *Fig.* 7. A jet of water of standard volume, pressure and temperature is directed against the bottom end of the sample and contacts only the end surface.

Thermal conductivity is substantially the same for all steels and the rates at which the sample piece will cool over its length during the Jominy test are known. Obviously cooling will be most rapid at the bottom end and slowest toward the top end. Also, since degree of hardness is dependent on cooling rate, the sample will be hardest at the quenched end and softest at the top end. Actual cooling rates are given in 1/16-

TABLE II—BOLTING AND SHAFTING STEELS*
(average properties)

Tensile Strength (min, psi)	Yield Strength (min, psi)	Elong. in 2 Inches (min, %)	Reduction of Area (min, %)	Brinell Hardness (approx)	Size Range	AISI Grades	Condition**	ASTM Spec.
60,000	33,000	22	50	143	All diam	C1019; C1020	HR AR	A-7-42
70,000	40,000	21	47	183	All diam	C1035	HR AR	....
80,000	50,000	20	45	187	All diam	C1042; C1045	HR AR	....
90,000	65,000	20	50	180–240	Over 4 in.	A8642; A8742; A4140	QT	....
95,000	70,000	20	50	190–250	4 in. and under	A8642; A8742; A4140 A3140; A2340	QT	A-193-45-T Grade BA
100,000	75,000	16	45	200–260	2 in. and under	C1042; C1045	QT	A-261-44-T Grade BO
100,000	75,000	20	50	210–270	4-7 in.	A8642; A8742; A4140; A3140; A2340	QT	....
105,000	80,000	20	50	210–270	4 in. and under	A8642; A8742; A4140; A3140; A2340	QT	A-193-45-T Grade BB
105,000	85,000	17	55	220–280	2½-4 in.	A8642; A4140; A3140; A8742; A2340	QT	A-193-45-T Gr. B7 & B12
105,000	90,000	17	55	220–280	2½ in. and under	A8642; A4140; A3140; A8742; A2340	QT	A-193-45-T Gr. B7 & B12
110,000	85,000	16	45	250–320	Over 4 in.	A8650; A8750; A4150; A4140; A4340		....
110,000	90,000	17	50	260–320	2½-4 in.	A8642; A8742; A4140 A3140; A2340	QT	A-193-45-T Gr. B7 & B12
115,000	95,000	17	50	260–320	2½ and under	A8642; A8742; A4140; A3140; A2340	QT	A-193-45-T Gr. B7 & B12
115,000	95,000	16	55	269–321	2½-4 in.	A8642; A8742; A4140; A3140; A2340	QT	A-193-45-T Gr. B7 & B12
125,000	105,000	16	50	269–321	2½ in. and under	A8642; A8742; A4140; A3140; A2340	QT	A-193-45-T Gr. B7 & B12
125,000	105,000	16	50	260–320	2½ in. and under	A8642; A8742; A4140; A3140; A2340; A4340	QT	A-193-45-T Gr. BC & B4
125,000	100,000	15	45	260–320	Over 4 in.	A8650; A4150; A4350	QT	....
135,000	115,000	15	50	240–340	2½ in. and under	A8642; A8742; A4140; A3140; A2340	QT	A-193-45-T Gr. B7
135,000	115,000	15	45	290–340	2½-5 in.	A8650; A4150; A6145; A4340	QT	A-193-45-T Gr. B4
135,000	115,000	15	45	290–340	Over 5 in.	A4340; A4150	QT	....
145,000	120,000	14	45	310–360	2½ in. and under	A8650; A8750; A4150; A6145; A4340	QT	....
145,000	120,000	14	45	310–360	2½-6 in.	A4150; A4340	QT	....
155,000	130,000	14	45	320–380	2½-4 in.	A4340	QT	A-193-45-T Gr. B4
160,000	135,000	14	45	320–380	2½ in. and under	A4340; A4150	QT	A-193-45-T Gr. B4

* From "Alloy Steel Reference Book", Joseph T. Ryerson & Son Inc., 1947.
** HR—Hot rolled; QT—Quenched and tempered; AR—As rolled.

inch intervals at the tops of the graphs, *Figs.* 8*a* and 8*b*.

With the cooling rates known, it remains to determine what hardnesses are effected in the steel at these various rates. Starting at the quenched end of the sample, Rockwell C hardness readings are taken at 1/16-inch intervals for a distance of two inches. These hardness values then are plotted on the graph and a curve drawn such as that marked "as quenched" in *Fig.* 9.

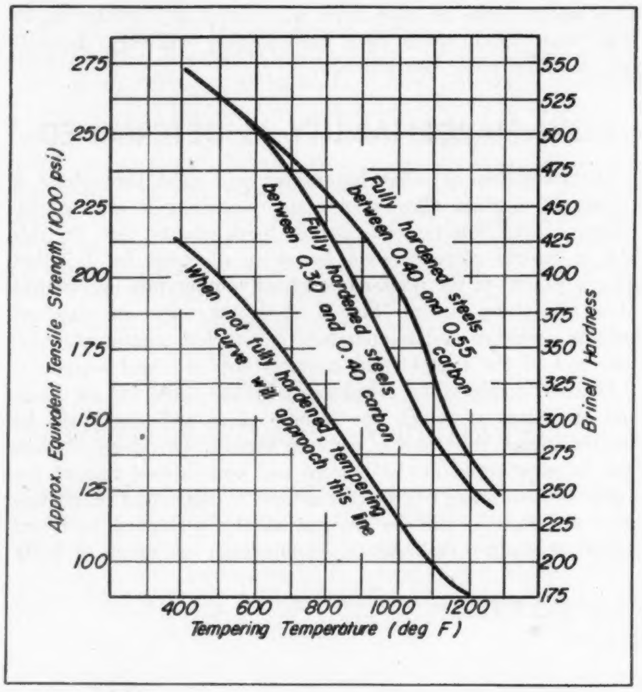


Fig. 5—Relationship between hardness and tempering temperature of carbon and alloy steels

The curves in *Figs.* 8*a* and 8*b* show cooling rates in steel bars 1 to 4 inches in diameter, at the surface, 3/4 radius, 1/2 radius, and center when quenched in still water (*Fig.* 8*a*) and still oil (*Fig.* 8*b*). These rates, of course, are the same for all steels.

Inasmuch as the cooling rates throughout round bars are known (*Figs.* 8*a* and 8*b*) and the hardnesses for a given steel which result from all commercially used cooling rates can be picked off end-quench curves, such as that of *Fig.* 9, the two types of data can readily be correlated to give the hardnesses throughout the structures of round bars of steels for which end-quench curves are available. Once this is done, all that remains is to determine the physical properties throughout the bar, and since these are dependent on hardness, they can be picked from Table III, which lists the approximate relationships between hardness and tensile strength, yield strength, elongation, and reduction of area.

The foregoing procedure has dealt specifically with steels in the as-quenched condition, whereas in by far the majority of applications alloy steels are employed in the *quenched and tempered* state. To determine the properties of a given steel as quenched and tempered, it is necessary to have end-quench curves applying to that steel in its as-quenched and tempered state (see three lower curves of *Fig.* 9). To obtain the data for these curves, the Jominy end-quench test is conducted exactly as already described, with the one exception that the sample is tempered after quenching before the hardness readings are taken.

Unfortunately, the end-quench hardenability curve-bands published jointly by AISI SAE apply only to steels in the as-quenched condition, and it is likely to be some years before "standardized" end-quench curves will be available for steels as quenched and tempered. Nevertheless, the presently available as-quenched curve-bands are of value to the designer in that they provide a means by which the hardenability of standard steels can be compared quickly when selecting or substituting steels for a specific application.

As soon as the latest hardenability bands are made available by American Iron and Steel Institute, they will be published in a subsequent Work Sheet, along with information on selection and specification of steels via hardenability.

APPLICATIONS

Machine parts listed in the following are indicative of present and past practice in the application of specific types of steel. It will be noted that certain parts are made of a number of different steels—an indication that for the majority of machine parts, any one of a number of steels will prove adequate if properly processed and heat treated. In the final analysis, selection always should narrow down to that steel which will meet design requirements at lowest overall cost.

TABLE III—PHYSICAL PROPERTIES IN RELATION TO HARDNESS*

Rockwell "C" Hardness	Brinell Hardness	Tensile Strength (psi)	Yield Point (psi)	Elongation in 2 inches (per cent)	Reduction of area (per cent)
14	197	93,000-103,000	69,000- 78,000	22-28	60-68
16	207	98,000-108,000	73,000- 84,000	21.5-27.5	59-67
18	217	103,000-114,000	76,000- 90,000	21-27.5	58-66
20	223	106,000-117,000	79,000- 93,000	20.5-26.3	57.5-65.5
22	235	112,000-124,000	85,000- 99,000	20-25.5	56.5-64.5
24	248	118,000-131,000	92,000-107,000	19.5-24.5	55-63
26	262	124,000-138,000	99,000-114,000	18.5-24	54-61.5
28	277	131,000-146,000	107,000-122,000	18-22.5	52-60
30	293	138,000-154,000	116,000-131,000	17-22	51-59
32	311	146,000-164,000	125,000-141,000	16-20.5	49-57
34	321	151,000-170,000	131,000-146,000	15.5-20	48-56
36	341	160,000-180,000	141,000-157,000	14.5-18.5	46-54
38	363	171,000-193,000	153,000-170,000	13.5-17	43.5-51.5
40	379	178,000-201,000	163,000-179,000	12.5-16	42-50
42	401	188,000-222,000	176,000-185,000	11-15	40-49

* From "Alloy Steel Reference Book", Joseph T. Ryerson & Son, Inc., 1947.

Note: These approximate physical relationships are based on hardness and apply only to fully quenched and tempered steels. Values listed will be more accurate for alloys of 0.30 per cent carbon and higher, because steels with less than 0.30 per cent carbon usually have yield points lower than those shown.

PLAIN CARBON STEELS:

C 1005-C 1010: Low in tensile and yield strength, but high in ductility and softness. Have poor machinability. For thin rolled sections or parts fabricated from bars requiring drastic cold deformations, or for parts requiring extremely soft, ductile cores when case hardened.

C 1012-C 1025: These are recognized as the standard grades of carburizing steels. Widely used for shafting and for semiheavy-duty parts that are cold upset, forged hot or cold, or punched. Typical parts are wrist pins, camshafts, drag links, clutch fingers, fan blades, welded tubing, etc. Have better machinability than steels in the C 1005-C 1010 range, but do not deep draw quite as well.

C 1030: Used for seamless tubing, key stock, shift and brake levers, shift forks and rails, brackets, etc. Responds better than foregoing steels to heat treatment, thus yields better physicals. Machines satisfactorily without annealing or

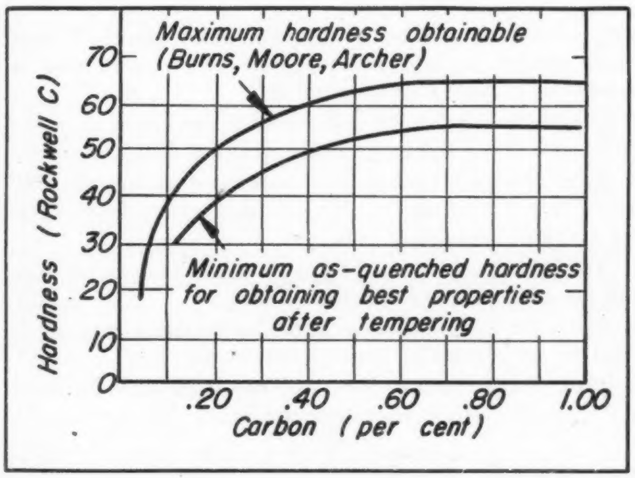


Fig. 6—Relationship between carbon content in a steel and hardness to which steel can be quenched

after simple normalizing. Suitable for case hardening where good core hardness is required.

C 1035-C 1036: For medium-size forgings requiring moderate physicals. Widely used, in wire and rod form, for cold upsetting. Bolts and screws under 3/8-inch diameter should not be water-quenched, because of danger of quenching fractures.

C 1040: Commonly used for tubing, crankshafts, connecting rods, tubular and solid axles, spring clips, brake levers, anchor bolts, studs, etc. Good hardening characteristics (Rockwell C 50-61, as quenched), and fair machinability. Care required in water quenching small-diameter or thin-sectioned parts.

C 1045: Used for the larger sizes of forgings such as crankshafts, ring gears, axles and spline shafts. Also some use for coil springs. As with C 1040, care is required when water quenching small-diameter or thin-sectioned parts.

C 1050: Used for parts of larger section size than are indicated for C 1045.

C 1052: Same as C 1050, but with higher manganese content.

C 1055: Widely used for coil springs.

C 1060: Used for snap rings, lock washers and springs (Rockwell C 45 to 50 recommended), spring clips, clutch disks, thrust washers, etc.

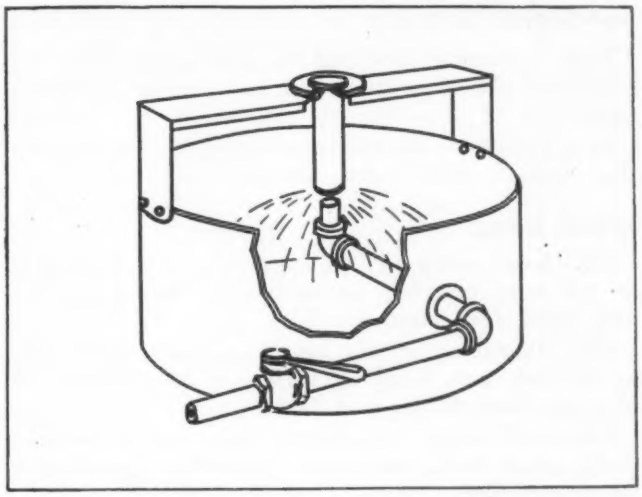


Fig. 7—End-quench hardenability testing fixture

C 1066: Applicable to coil springs of hard-drawn or oil-tempered wire and heat treated springs (Rockwell C 40 to 48 generally recommended).

C 1070: Extensively used in cold-rolled or planished form for clutch disks, and in agricultural industry for mower sections, plow beams, etc.

C 1080: In the agricultural field for parts such as plow shares, twine holders, knotter disks, springs, molds, shovels, harrow and plow disks.

C 1085: Used for bumper bars, lock pins, clutch disks, leaf springs, music wire, etc.

C 1095: Used for carbon steel balls, pins, keys, bumper bars, leaf springs and coil springs. In agricultural field, for harrow and seeder disks, seat springs, etc.

FREE-CUTTING STEELS:

B 1111: Commonly called bessemer screw stock. Generally used for screw machine parts. Has excellent machinability. Excellent strength in cold-drawn state and may be case hardened.

B 1112-B 1113: Screw machine stocks having better machinability than B 1111, Type B 1113 being the best of the three. Heat treatments are not recommended for these steels and they should be used only where speed of production and excellent finish are the paramount requirements.

C 1115: Somewhat inferior to the three steels immediately preceding in machinability, but of higher strength and toughness. Better too, for case-hardened parts and more suitable for operations such as bending, swaging, riveting and forming.

C 1117-C 1118: Used extensively for case-hardened parts which require good machinability. For drastic quenching of light sections where core toughness is essential, C 1117 is preferred.

C 1132: May be substituted for C 1035 and C 1040 where improved machinability, deeper hardening and higher physicals are desired.

C 1137-C 1141: Are primarily oil-hardening steels. Great care needed if water quenching is used. Good substitutes for C 1045 and C 1050 where improved machinability, deeper hardening and higher physicals are desired.

C 1145: Used for adapters, universal joints, yokes, crankshafts, etc. Substitute for C 1045 where improved machinability is desired.

(*Continued on next page*)

MANGANESE STEELS:

1320: Carburizing steel used for gears, spline shafts, etc. Particularly adapted for direct quenching from gas carburizing furnaces.

1330, 1335, 1340: Used interchangeably with other medium-alloy steels of similar carbon content.

NICKEL STEELS:

2317: A carburizing steel. Case quenches to file hardness in oil; thus water quenching seldom is used. Typical parts are lathe collets, feed fingers, etc.

2330: Typical applications are: Keys, heat treated bolts, screws, studs, nuts, levers, etc. Has good machinability and offers high strength plus good toughness.

2340-2345: Highly successful for parts such as propeller shafts, spline shafts, axle shafts, etc. Water quenching is not recommended.

5 PER CENT NICKEL STEELS:

2515: One of most dependable structural steels. Used for carburized parts which require exceptionally tough core after heat treatment. However, does not offer as high a degree of surface hardness as do some other comparable steels. Used for cams, heat exchanger tubes, chain pins, gears, etc.

NICKEL-CHROMIUM STEELS:

3115-3120: Primarily for carburized parts, but may be used quenched and tempered. Used for ring gears and pinions, spline shafts and countershafts, transmission gearing, piston pins, lathe collets, feed fingers, slush pumps, piston rods, etc.

3130: Used for cylinder studs, steering arm bolts, keys, nuts, connecting rod bolts, etc. For water-quenched parts where greater strength and toughness are required than is possible with the plain carbon steels.

3135-3140: For heat-treated structural parts such as crankshafts, axle shafts and spline shafts; links for drive chains, etc.

3141: Higher chromium and manganese variant of 3140 having better hardenability. For axle shafts, crankshafts, steering knuckles, connecting rods, etc.

3145-3150: Primarily used for gears of the oil-hardened type and for structural parts of heavy section.

3240: For parts requiring better hardenability than is offered by other steels of the nickel-chromium type.

3310: For carburized parts requiring high core toughness and strength such as rear axles and heavy duty gears.

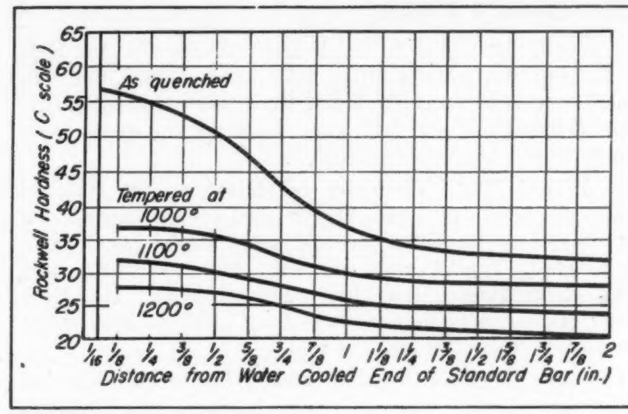


Fig. 9—Jominy end-quench curves show relationship between cooling rates and hardnesses resulting therefrom throughout section of given steel

MOLYBDENUM STEELS:

4023-4032: All steels in this range are carburizing types. For differential gears, countershafts, spline shafts, etc.

4037: May be used for large carburized gears; also applicable for certain types of studs and bolts.

4042: Oil-hardening type used extensively for steering arms, cold-headed bolts, studs, etc.

4047: Used as alternate for 3135, 4640 and 2340. Employed for spindles, synchronizing rings and similar applications requiring the quenched and tempered structure.

4063: Used for axle shafts, coil springs and flat or leaf springs less than ¼-inch thick.

4068: Applicable for flat springs over ¼-inch thick, equalizer bars, etc.

4130: Used to some extent for axles, steering knuckles, steering knuckle arms, connecting rods, etc.

4140: Extensively used for rear automobile axles, transmission shafts, aircraft bolts, nuts and studs, crankshafts, connecting rods, spline shafts, jordan bars in paper industry, chain links, sprockets, hydraulic pump impellers and piston rods, machine tool lead screws, etc.

4320: A carburizing steel having excellent core strength and surface hardness. Used for gears, chain pins, and similar high-strength parts.

4340: Suitable for oil-hardening gears, axle shafts, diesel engine crankshafts, and heavy-duty shafting over 2-in. diam.

4615-4620: Extensively used for carburized gears, shafts and other parts requiring high fatigue resistance and tensile

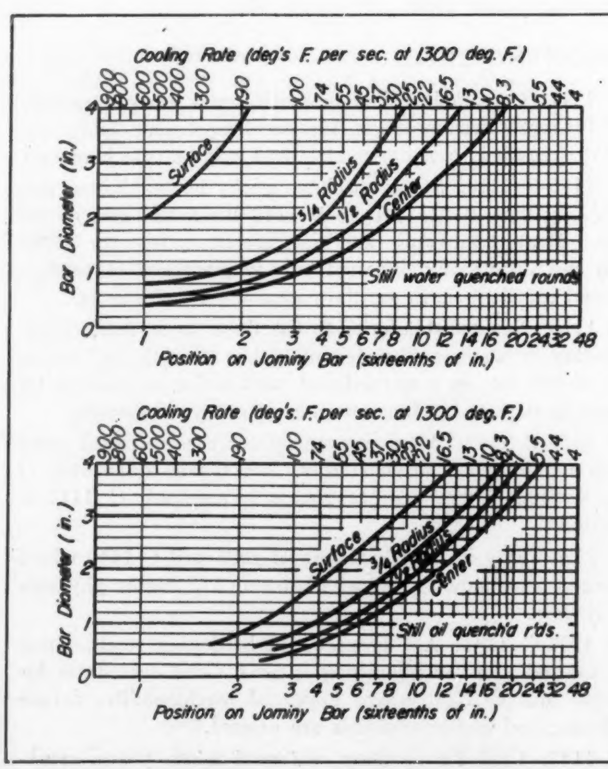


Fig. 8a (top)—Cooling rates throughout round bars when quenched in still water; 8b (bottom)—cooling rates throughout round bars quenched in still oil

TABLE IV—RELATIVE MACHINABILITY OF STEEL AS RELATED TO STRUCTURE AND CARBON CONTENT

Carbon Range	Type of Conditioning Heat Treatment	Type Structure	Relative Machinability in— Turning	Forming	Drilling	Broaching and Gear Generation
Low (0.08-0.30%)	Normalize and/or Anneal	Lamellar with Blocky Ferrite	Good	Good	Good	Good
	Quench and Temper*	Fine Spheroidite	Good	Good	Good	Good
Medium (0.30-0.50%)	Anneal	Coarse Spheroidite	Good	Poor	Fair	Poor
	Anneal	Lamellar	Fair	Good	Good	Good
	Quench and Temper	Fine Spheroidite	Fair	Fair	Fair	Fair
High (0.50-0.70%)	Anneal	Coarse Spheroidite	Good	Good	Good	Fair
	Anneal	Lamellar	Fair	Poor	Poor	Fair
	Quench and Temper	Fine Spheroidite	Good	Fair	Good	Good

* This treatment rarely is applied to low carbon bar stock, but frequently is used to condition forgings.
This table reproduced by courtesy of The International Nickel Co. Inc.

strength. Fine-grained types are excellent where minimum distortion is demanded.

4640: Excellent where parts require high fatigue resistance and generally high physicals. Fine-grained types outstanding where minimum distortion is demanded.

4815-4820: Often used interchangeably with 5 per cent nickel steel for gears, etc. Also used for steering knuckle pins, roller bearings, chain pins and high-strength studs and bolts. Have excellent core properties and surface hardness.

CHROMIUM STEELS:

5120: Has good hardenability in oil quench. Physical properties equal to those of 2317 and 3120 except that it does not have the tough fibrous core which characterizes the nickel and nickel-chromium steels. Typical parts are piston pins and bearing races.

5140: Used extensively for gears and shafts which are hardened by direct cyaniding. Can be employed interchangeably with 2340 and 3140 for heat-treated forgings requiring greater strength and toughness than are obtainable in plain carbon steel.

5150: Oil-hardening type of good hardenability used for gears, shafts, thrust washers, springs, etc.

E 52100: Used chiefly for races and balls or rollers of anti-friction bearings.

CHROMIUM-VANADIUM STEELS:

E 6150: Used for leaf springs, coil springs, gears, shafts and heavy forgings.

SILICON-MANGANESE STEELS:

9260: Used principally for leaf springs. General practice is to specify manganese on the high side for leaf spring sections of ⅜-inch and over, and low and medium manganese for sections under ⅜-inch.

FABRICATION

MACHINABILITY:

This subject is fraught with so many variables that there is not yet any standard test acceptable to all authorities. Arbitrarily established ratings often are rendered meaningless by improved machine tool design, cutting-tool designs and materials, plus cutting feeds and speeds which prove more effective than those considered conventional in material removal and surface finish. Nevertheless, investigations into this confusing subject point to certain factors which appear, at this time, to be reliable indicators of machinability.

It now is recognized that microstructure, not chemical composition, generally determines the relative machinability of alloy steels by any given method of machining. Further, no one type of microstructure is best for all methods. TABLE IV indicates, in general terms, the microstructures which appear to be best suited for various methods of machining.

Cold-drawn steels generally have better machinability than hot-rolled steels of the same analysis. Where permissible, addition of sulphur to a steel during its manufacture results in a distribution of insoluble inclusions throughout the structure. These mechanically interrupt chip formation and, consequently, improve machinability.

WELDABILITY:

Gas and arc welding are most commonly employed. Low-carbon (under 0.30 per cent), low-alloy steels are best for welding because they do not harden appreciably when heated and air-cooled, and consequently do not require heating of the welded area prior to welding (preheating). Welding of high carbon (over 0.30 per cent) high-alloy steels, however, generally is not recommended. Where such steels must be welded, care should be exercised to retain ductility by preventing the welded areas from cooling too rapidly. A satisfactory way to accomplish this is preheating the metal and maintaining the temperature at 400-600 F during welding. Then too, the metal should be normalized or annealed immediately after welding before cooling takes place. Steels of the A 2300, A 3100 and A 4100 series are weldable, providing the above precautions are practiced. *Suitability of a steel for welding decreases as its hardenability increases.*

However, recent research shows, that it is the presence of hydrogen in the quenched layer which makes the layer excessively brittle and, in this regard, the hydrogen content of the weld-rod coating is a big factor. The low-carbon, nonhardenable steels withstand use of high-hydrogen, cellulose-coated rods, because there is no hardened layer. Hardenable steels upon which low-hydrogen coatings are used, withstand hav-

TABLE V—COMPARATIVE FORGEABILITY OF STANDARD STEELS

(based on hot-twist test results)

(100 = greatest force required; also greatest deformation)

(1) Steel	(2) Force-Required-To-Deform Ratio	(3) Magnitude-of-Safe-Deformation Ratio	(4) Max. Recommended Forging Temp. (deg F)	(5) Forgeability Index
2512	58	48	2300	0.83
4620	58	52	2300	0.90
4640	48	40	2300	0.69
5120*	58	83	2300	1.43
3115	58	73	2250	1.26
1015*	61	100	2250	1.61
2317	61	79	2300	1.30
4615	61	64	2350	1.05
4017	64	57	2300	0.89
4820	64	65	2300	1.01
4047*	64	72	2250	1.13
4335	64	43	2300	0.67
4340	64	35	2300	0.55
8740	64	55	2200	0.86
52100	64	35	2200	0.55
8630	64	46	2250	0.72
3335	67	51	2250	0.76
6150	67	69	2250	1.03
1040*	67	89	2200	1.33
1010	71	64	2300	0.91
5140	71	46	2200	0.65
3135	71	65	2250	0.91
4063	71	43	2250	0.61
3140*	71	76	2250	1.07
6120	71	56	2250	0.79
6135	71	56	2250	0.79
8640	71	75	2200	1.06
2340	75	49	2200	0.65
4320	76	49	2250	0.64
8650*	76	69	2150	0.91
4135	76	57	2200	0.75
4032	77	51	2150	0.66
8735	77	44	2200	0.57
8620*	77	72	2250	0.94
52098	82	48	2100	0.58
9420	100	65	2050	0.65

* These steels are, on the basis of hot-twist tests, considered to be the most forgeable within their force-rating groups because hey offer the greatest amount of deformation per unit of force required to forge.

† Forgeability Index is equal to the ratio in Column 3 divided by the ratio in Column 2 for any given steel.

ing the hardened layer because it contains very little hydrogen. Heat treated steels seldom are welded because the welding heat changes the physical properties imparted by the heat treatment.

FORGEABILITY:

All of the standard steels are forgeable, although some are more difficult to forge than others. Power required to forge steels generally increases with carbon content, and the greater the power required the shorter the forging-die life. As is generally recognized, coarse-grained steels are more readily forged and are easier on the forging dies than are fine-grained steels.

Indication of the relative power required plus the amount to which steels can be deformed without structural damage at their optimum forging temperatures is given by C. L. Clark* in a series of curves depicting the results of a number of hot-twist tests. The comparative ratings listed in Table V are derived from these curves.

* C. L. Clark—"Evaluating the Forgeability of Steels"—Timken Roller Bearing Co.

In using the table, it should be remembered that its basis (hot-twist tests) is not claimed to be the final, perfect criterion for evaluating forgeability. The table is offered only as another tool to be used along with others, in particular, experience, in the selection of steels for forgings. Viewed in this light, it it suggested that selection be conducted as close to the top of the table as strength requirements of an application will permit. In addition, where feasible, those steels marked with an asterisk(*) in the table should be favored, inasmuch as they presumably offer the optimum relationships beween force required and magnitude of safe deformation (highest forgeability indexes).

HEAT TREATMENTS

Steels are hardened by heating to a high temperature followed by rapid cooling. (Cold working also will harden steels but, obviously, is not a heat treatment.) The cooling (or quenching) may be done in air or in a liquid such as water or oil. Steel of as-quenched hardness, however, is too hard and brittle for most applications and, in addition has within its structure an

abundance of internal stresses. By again applying heat, this time below the hardening temperature, and allowing the metal to cool more slowly than when hardening, brittleness and hardness are modified and the internal stresses are relieved. This second heating and cooling cycle is commonly referred to as tempering or drawing.

Quenching in water or brine tends to accentuate distortion and in fact may lead to cracking or spalling in steels containing over 0.35 per cent carbon. Oil quenching, being less drastic, minimizes these adverse effects and should, therefore, wherever practicable, be specified. This is particularly true of parts of intricate shape and which have sudden changes of section cross-sectional area.

DESIGNING QUENCHED AND TEMPERED PARTS:

Filleting of corners should be as generous as part function will permit, because sharp corners give rise to stress concentrations and drastically weaken parts. Areas of part sections should be designed as closely uniform as is feasible, because sudden changes in section tend to produce distortion of the part during quenching. It is well to bear in mind also, that elastic deflection of a given part will be the same regardless of the type of steel used or its heat treatment. If elastic deflection is excessive, only change in design can decrease it; using a different steel or a different heat treatment will not help in the least.

CASE HARDENING:

All methods of case hardening involve adding carbon or nitrogen (or both) at and near the surface of either straight-carbon steels or some alloy steels. Generally the steels have low or medium carbon content in their normal structure and, by adding carbon and/or nitrogen at their surfaces by carburizing or nitriding at high heat (1500 to 1700 F depending on the steel) and then quenching, a shell or case of hardness considerably higher than the core is developed. This hard case not only has good wear resistance but, since hardness means tensile strength, it also adds to the strength of the part.

In specifying depth of case for a machine part, it should be borne in mind that the deeper the case the longer the time required to produce it, and time costs money. Depth of case procurable in eight hours generally ranges from 1/32 to 1/16 inch. However, to double this depth, about 24 hours would be required.

ANNEALING:

While various types of annealing are practiced (full, spheroidizing, "bright", etc.), all constitute heating the steel to a high temperature and cooling very slowly. Steels are annealed for one or more of the following reasons:

1. To soften the steel and thus make it easier to machine, cold work, form, etc.
2. To refine the structure of the steel
3. To relieve internal stresses incurred during rolling, forming, cold drawing, cold straightening etc.

NORMALIZING:

Normalizing is almost the same as annealing, the primary difference being that in normalizing the steel is cooled from high temperature in still air, whereas in annealing cooling is effected more slowly in a furnace or in annealing boxes. Improvement of grain structure is the primary function of normalizing.

FLAME HARDENING:

Where localized hardening of parts made of steels having carbon content of about 0.45 per cent is required (teeth on large gear, for example), flame hardening often may be used advantageously. The process consists of moving an oxyacetylene flame along the surface at a rate which insures proper heating and immediately quenching with a spray of cold water. The resulting "case" of hardened steel thus locally obtained may be roughly compared to that obtained in case hardening, although the surface hardness may not be as high.

INDUCTION HARDENING:

This is similar to flame hardening, except that the source of heat is electrical. The part to be hardened is placed manually or automatically, in an induction coil through which a high-frequency alternating current is passed. The part will be heated in proportion to the square of the amperage times the resistance of the part. Heat will be generated largely on the part surface and depth to which heat will be induced will be in inverse proportion to the frequency or reversals of current in the coil. Thus, for shallow hardening, high frequencies—100,000 to 300,000 cycles per second—are employed, while for deeper, through hardening, lower frequencies—2000 to 20,000 cycles per second—are used.

Immediately after the part has been heated properly it is quenched either by a water spray or by dropping into a tank containing the quenching medium. When shallow hardening is required, carbon steel generally is used. For deeper hardening, alloy steels must be employed. Induction heating offers close control of heating temperature and of heat location, and is extremely fast, the entire heating and quenching cycle being accomplished in a matter of seconds. It is ideally suited to automatic mass production.

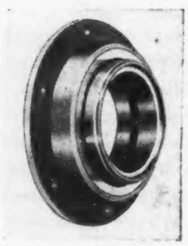
RESISTANCE TO CORROSION

When uncoated, all of the standard carbon and alloy steels will rust in atmospheric, fresh-water, or sea-water exposure. While the alloy steels, such as the nickel and nickel-chromium types, are more resistant than the plain carbon steels, they do rust and are not comparable in corrosion resistance to the standard stainless steels or metals such as Monel, nickel-silver, copper, brass, etc. Where corrosive conditions exist, the steels are best protected by suitable paints and enamels, or metallic coatings such as zinc, tin, cadmium, lead, chromium and nickel.

new parts and materials

To obtain additional information on these new developments see Page 269

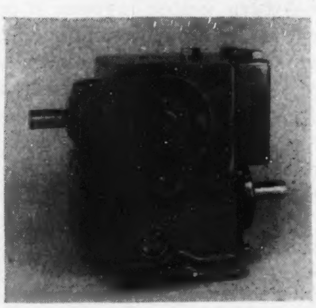
Carbon Ring Oilseal



SEAL designed for conditions of poor lubrication, such as very high speed or minimum supply of lubricant, is designed around entirely new principle, completely eliminating wear on shaft and the replacement of grooved shafts. The assembly, known as the Gits DMC and DPC high-speed carbon-faced seal, effects a perfect seal against leakage of liquids or gases under pressure or vacuum by means of a radial seal joint made by positive contact between a stationary lapped-seal surface built into the unit and a rotating lapped-seal surface. These do not contact or wear the shaft surface but transfer the wear to the radial seal joint instead. Units are applicable to both horizontal and vertical shafts. Manufacturer: Gits Bros. Mfg. Co., 1846 S. Kilbourn Ave., Chicago 2.

For further information circle MD 1 on card Page 269

Variable-Speed Transmissions

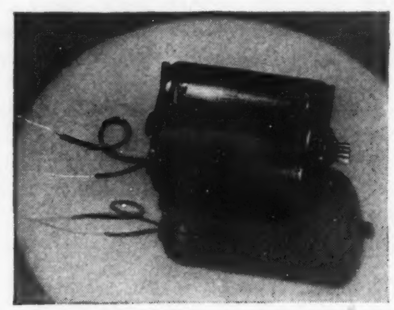


SMALL SIZE hydraulic variable-speed transmission provides infinitely variable speed from drive speed forward through zero to drive speed reverse. Rated at one horsepower, 52½ lb-in torque, the drive is an entirely self-contained unit and does not require any separate oil sump or reservoir tank of any kind. The transmission is of the multiple-piston, constant-torque type and may be furnished with various systems of speed controls, including manual and remote types. The smallest unit in the Portman line measures 9¼ inches high, 11 inches long over shafts, and 7 inches wide. It is identified as model T-1. Manufacturer: Portman Machine Tool Co., 70 Portman Road, New Rochelle, N. Y.

For further information circle MD 2 on card Page 269

Fractional-Horsepower Motor

UNIVERSAL MOTOR weighing 14 ounces will produce up to 1/20-hp, and 4 oz-in. torque. The type 597 motors are available in three styles: 1/20, 1/40, and 1/70-hp for 117 or 6-volt operation and measure 3¼ by 2 7/32 inches. Rated at 4 oz-in. torque at 12,700 rpm, the 1/20-hp motor has a 15 oz-in. starting torque and 20,000 rpm no-load speed. Its temperature rise is 56 C on one-hour duty cycle. The 1/40-hp unit is rated 3 oz-in. torque at 8400 rpm for a 52 C temperature rise on a one-hour duty cycle; starting torque is 10 oz-in., and no-load



speed is 15,000 rpm. 1/70-hp motor, with a 2.5 oz-in. torque rating at 5800 rpm, has a 40 C temperature rise. Starting torque is 5 oz-in. and no-load speed is 10,000 rpm. Shaft diameter on all units is ¼-inch. Motors are recommended for domestic appliance applications, and control mechanisms, and various automotive uses. Manufacturer: Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

For further information circle MD 3 on card Page 269

Magnetic Relays

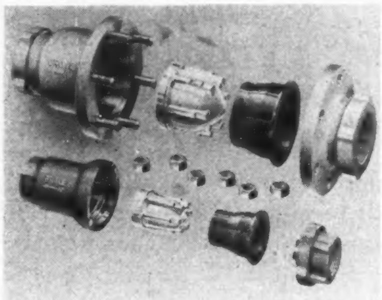
LINE of magnetic general-purpose relays includes 3-ampere contact types available in combinations up to six-pole double-throw for low-voltage application, as well as relays rated at 12 amperes 115 volts. Units are designed to Underwriter's specifications and cover the field of general purpose ac and dc magnetic relays. Manufacturer: R-B-M Division, Essex Wire Corp., Logansport, Ind.

For fruther information circle MD 4 on card Page 269

Check Valve

EMBODYING no metallic operating parts, new simplified line of check valves operates on low pressure differential, is available in sizes from ½-inch to 12 inches. Units, known as Chexflo, utilize tough, flexible, tubular operating member comprised of a thick load-section tapering down to a sensitive operating lip. They thus require little differential pressure to effect positive shut off. Synthetic lip freely opens to expand, permitting unrestricted streamline flow. Owing to its resilient nature, the lip smoothly contracts to close on slack flow, prior to

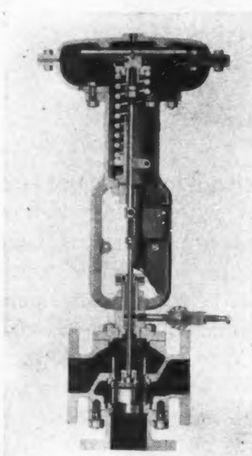
back flow. In open and closed position it is fully supported against extreme pressure or intensive impulse shocks by the inner walls of the valve body and the cylindrical acorn-shaped core. As it reaches shut-off



position, flow velocity increases to flush the seating surface of any small particles. The resiliency of the flexible tube completely absorbs any shock impulses. Manufacturer: Grove Regulator Co., 65th and Hollis Sts., Oakland, Calif.

For further information circle MD 5 on card Page 269

Three-Way Control Valve



AIR-OPERATED control valve line is recommended for diverting or mixing service. For diverting, the fluid is divided into partial flows of varying ratios; for mixing, two different fluids are accurately proportioned in varying degrees. In both cases the control disk provides tight shut off in either end position. Unit with mid position shut off is specified for intermittent service. This special unit controls the flow of one fluid in the first part of the control range and the flow of the second liquid in the remaining part. Mixing of the two fluids is avoided by mid position shut off. Specified pressure drop remains constant across the valve body regardless of the position of the controlling disk. Series of valve plugs are available to meet diversified process requirements. Manufacturer: H. Belfield Co., Broad St. at Hamilton, Philadelphia 23.

For further information circle MD 6 on card Page 269

Forged Fittings

LINE OF drop-forged pipe fittings for welded assemblies includes 90 and 45 degree elbows, 180-degree return bends, tees, reducers, caps, saddles, crosses, etc., in sizes up to 30 inches. Features of the line include uniform wall thickness, circularity, full radii, smooth walls, and machined bevel ends. Manufacturer: Ladish Drop Forge Co., Cudahy, Wisc.

For further information circle MD 7 on card Page 269

Snap-Action Switch

MINIATURE snap-action switch of the precision type is no larger than a dime. Known as the Q-Switch, the unit has a high current-carrying capacity and long life and is designed for applications where only a limited space is available. Models may be obtained in almost any circuit combination such as normally-open, normally-closed, single or double-throw, or single-pole. Switch is recommended for such machines as linotypes, timers, washing machines, dispensing machines, and dictating equipment. Manufacturer: Mu-Switch Corp. Inc., Canton, Mass.

For further information circle MD 8 on card Page 269

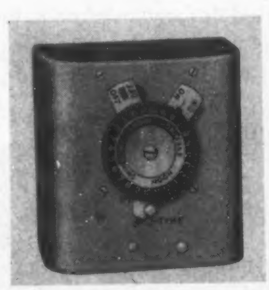
Single-Cylinder Engine

AIR-COOLED, single-cylinder engine having a four-stroke cycle is said to be particularly suited to such applications as general utility equipment, compressors, lawnmowers, etc. The 1½-hp unit is of the L-head type,

cooled by a blower-style flywheel shrouded to force air over the large cooling fins on the cylinder and head. The motor, which is known as model AA7, reaches its rated horsepower at 2400 rpm. Manufacturer: Continental Motors Corp., 12601 E. Jefferson Ave., Detroit 14.

For further information circle MD 9 on card Page 269

Time-Cycle Controller

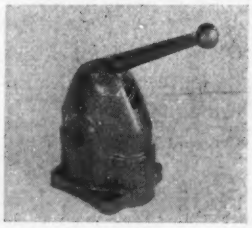


TIME SWITCH for appliance control is designed to operate on a 24-hour cycle and can be set for either repeating or nonrepeating operation. Capable of handling 750-watt lamps, 1000-watt heater elements, 3/4-hp repulsion-induction, condenser or capacitor motors or ¼-hp split-phase motors, the timer actuates a single-pole single-throw switch. Two simple settings of timer are required. The "on" arm on the dial is moved to the time the appliance is to start, and the "off" arm is set at the time it is to go off. Control face is divided into

day and night hours with each hour graduated into quarters for accurate setting. Unit may be operated manually by simple auxiliary switch without disturbing the automatic settings. Control measures 4 3/8 inches high, 3¼ inches wide and 2 inches deep; requires 115-volt, 60-cycle power. Manufacturer: Holcomb & Hoke Mfg. Co. Inc., Indianapolis 7.

For further information circle MD 10 on card Page 269

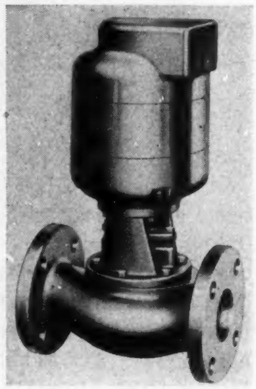
Air Valves



LINE OF hand-operated air valves using the balanced-piston principle are designed principally for pneumatic cylinder control and are provided with a 3-position lever. The valves are cast aluminum alloy, designed and manufactured for 175 psi maximum pressure with all inner parts of stainless steel and bronze. Manufacturer: Lindberg Engineering Co., Air and Hydraulic Division, 2450 W. Hubbard St., Chicago 12.

For further information circle MD 11 on card Page 269

Circulating Pump



CENTRIFUGAL circulating pump is provided with opposing inlet and outlet for standard 125 lb, 2-inch pipe flanges. The unit is provided with a driving motor direct connected to the pump for compactness. The motor is a totally enclosed type equipped with grease-packed, sealed, precision ball bearings and no added lubrication is necessary. Motor stator is dynamically balanced by Dynetric process to extremely close limits, insuring vibrationless and quiet operation. The model 1-B unit can be installed on pipe lines of various sizes by use of pipe reducers and may be operated in any intermediate angle from a vertical to horizontal position. Manufacturer: The Ruthman Machinery Co., 1811 Reading Rd., Cincinnati 2.

For further information circle MD 12 on card Page 269

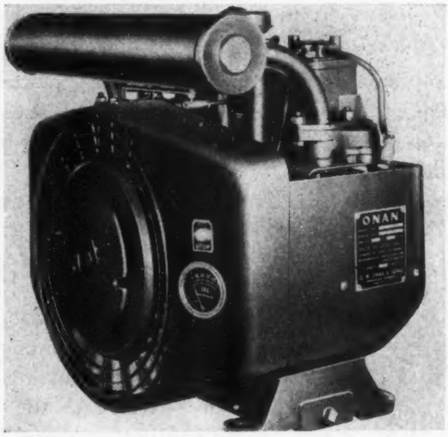
Synchronous Motor

SELF-STARTING synchronous motors measuring only 2 by 2⅜ by 1¼ inches are available in speeds from 1 to 60 rpm and will produce as much as 10 oz-in. torque at 1 rpm. The motors, which are designed for operation at voltages from 1 to 250 and frequencies from 25 to 120 cycles, are available for either clockwise or counterclockwise operation and weigh only 9 oz. Among applications for which the motors are recommended are timers, controllers, and instrument movements. Manufacturer: Kurman Electronics Corp., 130 Clinton St., Brooklyn 2, N. Y.

For further information circle MD 13 on card Page 269

Ten-Horsepower Engine

TWO-CYLINDER, FOUR-CYCLE ENGINE weighs only 97 pounds, yet produces 10 horsepower. The new Onan CK engine is an air-cooled heavy-duty unit of opposed-piston design in which each cylinder is provided with over 340 square inches of cooling surface. Unit is of aluminum construction to reduce weight and take advantage of increased thermal conductivity. Opposed-cylinder design eliminates interference with cooling-air flow making it a cool-running motor. Bearing surfaces have been made almost twice as large as comparable units. Also available is a direct-connected electric starter-generator, built into flywheel greatly reducing the overall size of the engine. Manufacturer: D. W. Onan & Sons Inc., 43 Royalston Ave., Minneapolis.



For further information circle MD 14 on card Page 269

Heat-Transfer Unit

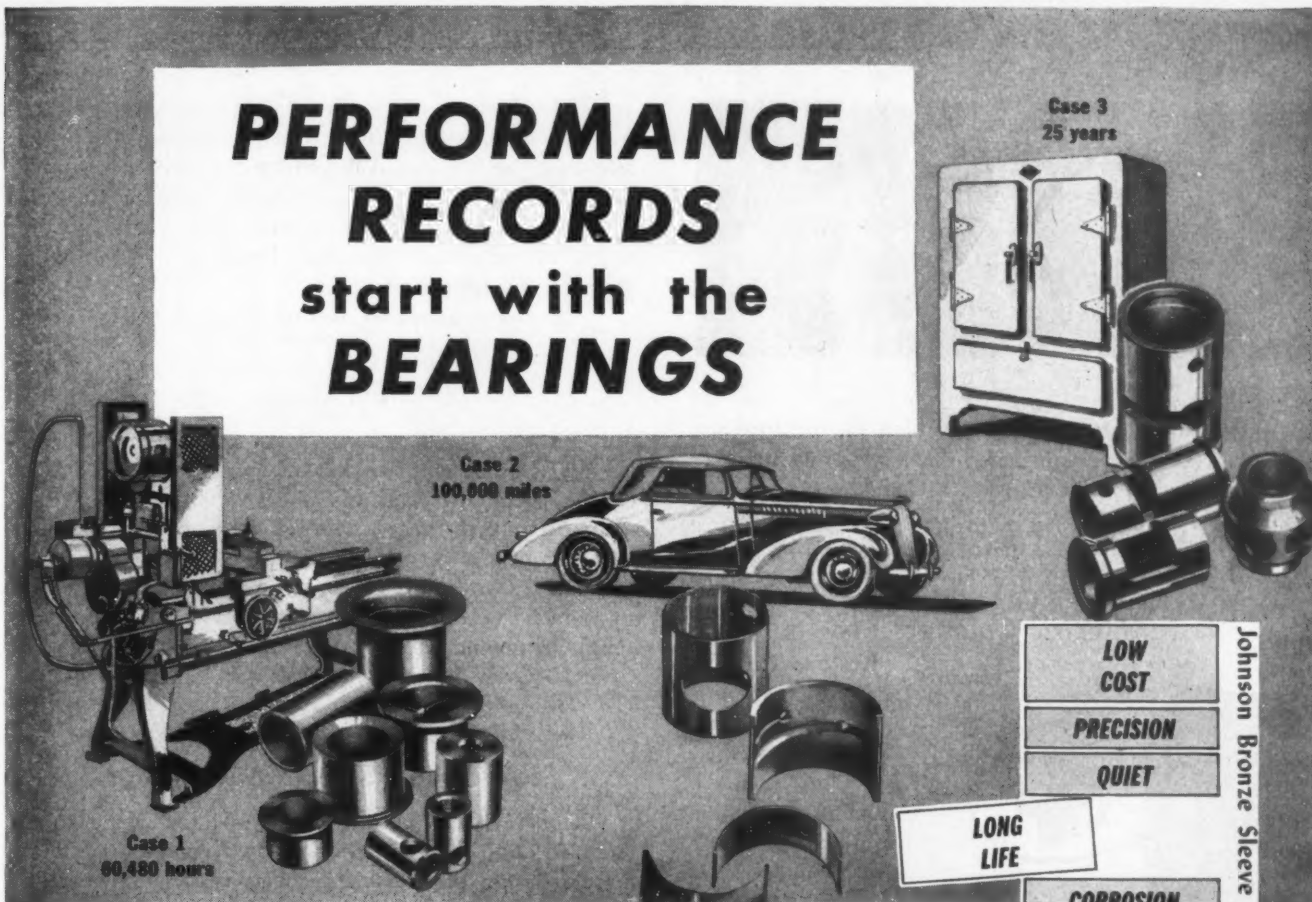
HEAT EXCHANGER known as the Aridizer has been brought out by Goodyer Industries, Inc., 224 S. Michigan Ave., Chicago 4. In one unit the Aridizer utilizes the principle of heat transfer for the heating of air and other gases, and superheating of steam. Temperatures up to 1000 F can be maintained with control of leaving temperatures held to within plus or minus one degree Fahr. Unit is small and compact and heating may be effected by Calrods or oil and gas burning equipment.

For further information circle MD 15 on card Page 269

Powder-Metal Bearings

STANDARD LINE of self-lubricating cylindrical bearings is designed for automotive, aircraft, machinery and appliance applications. Bearings in the standard line are bronze, but a new copper-tin-lead alloy is also available

PERFORMANCE RECORDS start with the BEARINGS



Johnson Bronze Sleeve Bearings Give You Every Worthwhile Advantage

- LOW COST
- PRECISION
- QUIET
- LONG LIFE
- CORROSION RESISTANT
- UNIT CONSTRUCTION
- LOAD CARRYING CAPACITY
- HIGH RESISTANCE TO SHOCK
- LOW COEFFICIENT OF FRICTION
- EASY TO INSTALL
- CONFORMABILITY
- NATION WIDE SERVICE

BUYERS of all types of equipment are becoming more particular. Besides checking the price, they're asking . . . "How long will it run . . . at top efficiency . . . at lowest operating cost?" Performance records are becoming a major sales factor.

No mechanical unit can be any better than its bearings. The only way to be sure of your bearings is to: 1. Determine the *correct* type for each application and 2. Get bearings made to your specifications.

Johnson Sleeve Type Bearings have achieved an enviable reputation for long life and economical operation. Our up-to-date methods . . . our skilled help . . . and more than forty years of exclusive bearing experience . . . . enable us to help manufacturers create new performance records. We help you decide which types of bearings will best serve your needs . . . we will produce them exactly to your specifications . . . and we can deliver them *on time*. Why not call us in NOW?

JOHNSON BRONZE CO.
525 South Mill Street New Castle, Pa.

JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS
BRANCHES IN 18 INDUSTRIAL CENTERS

Case 1

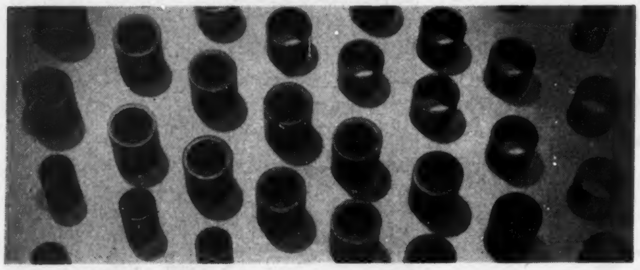
A prominent user of machine tools reports that the Johnson Sleeve Bearings installed in one of his units in 1927 are still operating efficiently after 60,480 hours of service.

Case 2

A traveling salesman tells us of the Sleeve Bearings installed in his car . . . 1937 model. After over 100,000 miles they are still delivering economical performance.

Case 3

A refrigerator owner reports that in a recent overhaul he checked the bearings. After twenty-five years of continuous service the Johnson Bronze Sleeve Bearings show no signs of wear.



that is said to counteract shaft irregularities and to eliminate damaging wear during initial operating period. Manufacturer: Wel-Met Co., 110 Gougler Ave., Kent, Ohio.

For further information circle MD 16 on card Page 269

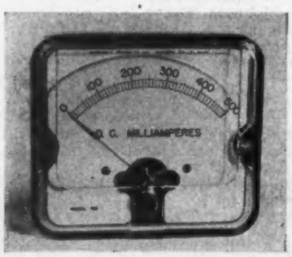
Electric Counters

Rear View of Counter showing Terminals for wiring connections.

ELECTRICALLY-OPERATED electric counters designed specifically for panel mounting may be installed, reset and read from front of panel. Any number of counters may be grouped on a centralized-count control panel, either together or with other instruments. Units consist of Wizard counter equipped with subpanel for attaching purposes. Counters are actuated by electric impulses which may originate from any suitable switch, relay or photo electric device. Made in 4 and 6-digit models, with either knob or key reset, units can be furnished for any voltage up to 220 ac or dc. Manufacturer: Production Instruments Co., 702-08 W. Jackson Blvd., Chicago 6.

For further information circle MD 17 on card Page 269

Panel Meters



ADVANTAGE IS TAKEN of the "light-piping" property of certain plastics in the new line of panel-type electrical instruments. Front case of the instruments is clear plastic allowing the light played on back of instrument to be refracted to the front, fully illuminating the dial. Clear housing also provides more space on front of instrument, giving larger dial for a given size instrument than normally available. Meters, which are available in both the rectifier and thermocouple types, can be supplied with either iron-vane or moving-coil movements for all popular ranges of voltmeters, or ammeters. Housing measures 3 3/8 by 3 3/4 inches, protrudes 5/8-inch in front of panel. Manufacturer: Assembly Products Inc., Main and Bell Sts., Chagrin Falls, Ohio.

For further information circle MD 18 on card Page 269

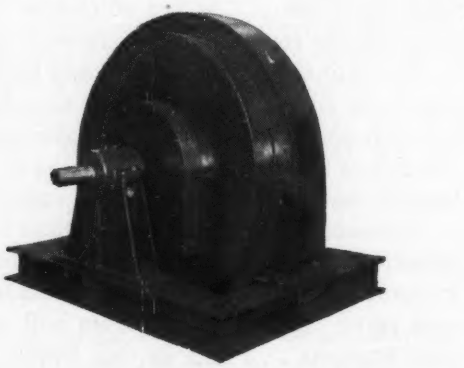
Oil Gage

LINE OF straight oil gages are machined from hexagonal bar stock and have a heavy central stem and top cap supporting unbreakable plastic sights. Independent nut locks unit together compressing the gaskets and eliminating any chance of leakage. Standard sizes cover the range of 2½ to 5-inch gages, having sight diameters of ½ to ⅜-inch. Gages can be taken apart for cleaning by simply removing the top nut. Manufacturer: Oil-Rite Corp., 3476 S. 13th St., Milwaukee 7.

For further information circle MD 19 on card Page 269

Low-Speed Synchronous Motors

SPLASHPROOF construction has been added to the modified GE line of low-speed synchronous motors. Simple design of end-shield covers makes their removal and assembly easy when inspecting the motor. Pedestal bearings are outside the housing, permitting regular inspection of oil supply and oil ring operation. The new construction saves floor space since it has louvered open-



ings for side air discharge instead of flared-skirt type of opening. Also, the conduit box is included in the frame structure of the motor to protect it from splashing liquids. An inspection window is provided in the air chute for viewing the brush holder and collector without removal of the covers. Manufacturer: General Electric Co., Schenectady, N. Y.

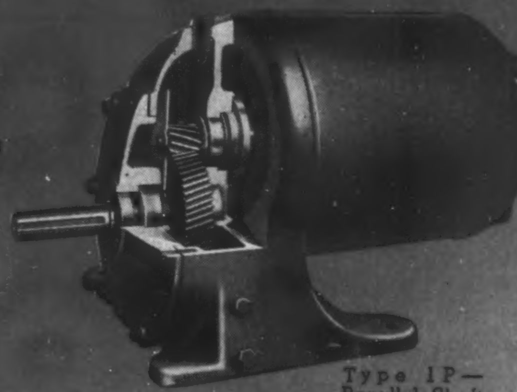
For further information circle MD 20 on card Page 269

Latching Relay

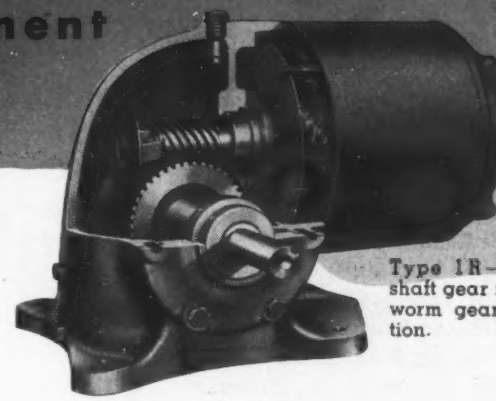
DYNAMIC BALANCE of moving parts in new latching relay provides exceptional freedom from the effects of vibration and shock. Mechanical wear is said to increase rather than lessen latching stability, resulting in life up

CENTURY
Fractional Horsepower
GEAR MOTORS

Are Engineered to Maintain the High Torque Slow Speed Shaft in Rigid Alignment



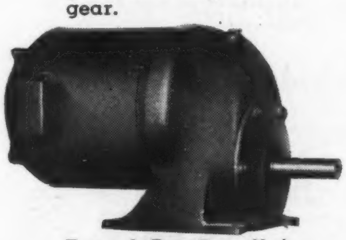
Type 1 P—Parallel Shaft Gear Motor, one step speed reduction.



Type 1 R—Right angle shaft gear motor, one step worm gear speed reduction.

Type 1 R—Right angle shaft gear motor, one step worm gear speed reduction.

Type 2 R—Right angle shaft gear motor, two step speed reduction—one step helical gear, one step worm gear.



Type 1 P—Parallel shaft gear motor, one step helical gear reduction.

Type 2 P—Parallel shaft gear motor, two step helical gear reduction.

The mounting feet of Century Gear Motors are an integral part of the rugged compact gear housing—provides a strong, rigid unit. Additional mechanical strength is achieved by locating the shaft close to the base of the gear housing. This method of construction holds the high torque slow speed shaft in rigid alignment, and reduces stresses.

The motor is equipped with ball bearings. Large taper roller bearings in the gear unit handle heavy radial or thrust loads.

Century Gear Motors are built in standard sizes from 1/8 to 3/4 horsepower — single phase, polyphase and direct current.

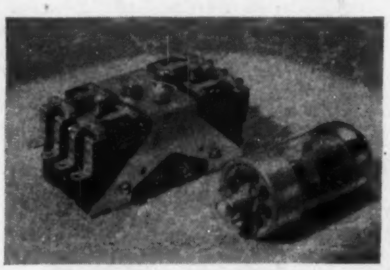
Century's line of fractional horsepower gear motors has gained an enviable reputation for outstanding performance. Many thousands of them have been put into service since their introduction eight years ago

Specify Century Gear Motors for all your fractional horsepower slow speed requirements

Century C Motors

CENTURY ELECTRIC CO.
1806 Pine St., St. Louis 3, Mo.
Offices and Stock Points in Principal Cities 560

to the millions of cycles. Multicircuit unit has eight individual switch positions, each of which may be normally-open or normally-closed. Contacts may be ganged or arranged in pairs for a maximum of four double-break circuits; are rated at 5 amperes at 110 volts ac or 24 volts dc. Coils, which operate from dc or rectified ac, require pulses of less than 0.5 watt for tripping and are available with resistances from very low values up to 10,000 ohms. For some types of memory applications where vibration is not severe and simple contact combinations suffice, a high



sensitivity adjustment is provided and power requirements are as low as a few milliwatts. In this type of service the relay can be tripped by a 50 volt charge on a ¼-mfd condenser. Common applications range from momentary-contact controls to various protective circuits including electronic tube overload or underload. Manufacturer: Sigma Instrument, 70 Ceylon St., Boston.

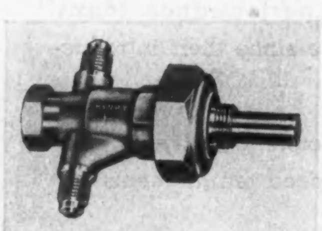
For further information circle MD 21 on card Page 269

Protective Finish

ANTICORROSIVE protective finish said to afford 20 years protection to ferrous metals is unaffected after 1000 hours exposure in standard salt-fog equipment. The process known as Zincilate is a one-coat protective coating. It possesses remarkable abrasion resistance and even when sizable areas are destroyed by scraping or wear lasting protection is assured through cathodic sacrifice. Manufacturer: Indudstrial Metal Protectives Inc., Dayton, Ohio.

For further information circle MD 22 on card Page 269

Push-Button Valve



PACKLESS pushbutton valve is suitable for handling oil, air, water or any other substance not corrosive to brass. Valve is of the normally-open type, and it has been carefully designed for service where either manual or automatic instantaneous valve operation is desired, and where leakage around conventional packing would be objectionable. The unit has a renewable disk, renewable diaphragm, and a threaded collar around the pushbutton, permitting it to be mounted through a flush-panel opening. It is suitable for pressures up to 100 lb, can be furnished with male SAE, IPS, or female solder connections in sizes from ¼ to ½-inch, inclusive. Manufacturer: Henry Valve Co., 3260 W. Grand Ave., Chicago 51.

For further information circle MD 23 on card Page 269

Self-Locking Nut

LOCK NUT similar in appearance to a flat-wire helical spring is available in either the conventional nut or spring-nut types. Well adapted by its shape to hopper feed systems, unit known as Diamond G spring nut, has good gripping power and strength yet is low in price. Manufacturer: George K. Garrett Co., 1421 Chestnut St., Philadelphia 2.

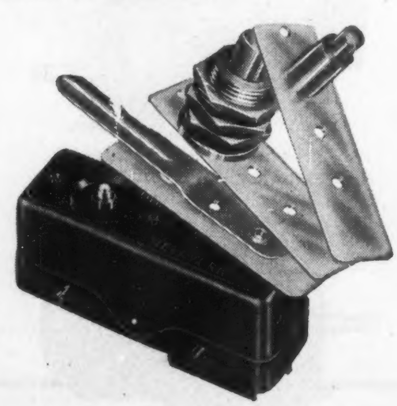
For further information circle MD 24 on card Page 269

Hopper Feeder

VIBRATORY FEEDER will cause material in granule form to flow upward at a continuous, even rate. The spiral hopper-feeder consists of an aluminum helicoid formed of individual 360-degree stampings Argon-welded to form a continuous screw or ramp. Material poured into hopper at base of feeder is forced upward by a vibratory motion of 3600 cycles per minute. Model shown in the accompanying illustration is 8 ft high, raises granules 7 ft while traveling them over 50 ft. Area occupied by unit is only 20 by 20 inches. Manufacturer: Miskella Infra-Red Co., East 73 and Grand Ave., Cleveland 4.

For further information circle MD 25 on card Page 269

Switch Actuators

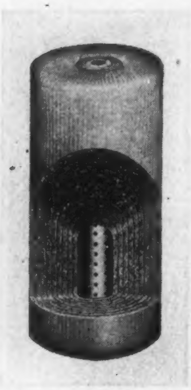


INTERCHANGEABLE and removable actuators for the Unimax snap-action switch allow the basic switch to be adapted to a variety of applications. To achieve a uniform relationship between actuators and switch button, actuators are mounted on stainless-steel plates which are in turn fastened to the switch body by locating screws. Strong forces may be applied to the assembly without fear of

failure since the loads are distributed over a large area. Electrical ratings for the basic switch are 15 amp at 125 volts, 5 amp at 250 volts, or ½-hp. All units are the single-pole double-throw type. Manufacturer: Unimax Switch Corp., 460 W. 34th St., New York 1.

For further information circle MD 26 on card Page 269

Oil Filter



FABRIC-TYPE oil filters consist of lint-free textiles wrapped in a closely knit muslin cloth, pressure-wound in convolutions around a perforated metal core. The whole is covered with a heavy tubing or muslin jacket. Flow of oil from outside to inside, leaves dirt and sludge within the body of the filter. As elements absorb contaminants they expand, allowing great dirt-storage capacity. The new-type filters are said not to remove additives from oils, and to be usable with any type of oil; they are applicable to use on engines, pipe lines and machine-tool coolant systems. Elements are available in 260 sizes to fit all popular makes of filter cases and no adapters or springs are required. Manufacturer: Engine Life Products Corp., El Monte, Calif.

For further information circle MD 27 on card Page 269

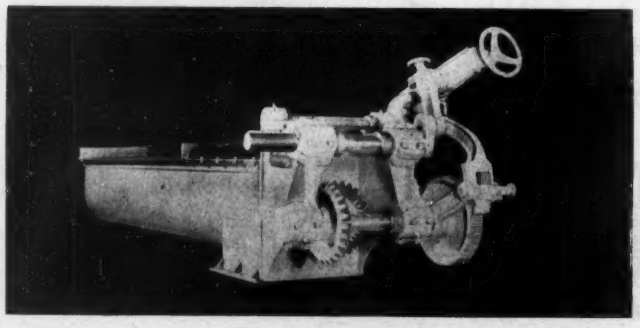
Flexible Connector

DESIGNED to protect pumps and similar apparatus against vibration and pipe expansion, a new flexible, seamless bronze hose with floating flanges is now being marketed by Seamlex Co., Inc., 41-23 24th St., Long Island City, N. Y. Floating flanges are of open-hearth steel with American Standard drilling. The inner bronze tube is of the close-pitch corrugated type reinforced by a high-tensile bronze braid jacket.

For further information circle MD 28 on card Page 269

Variable-Speed Feeder Drives

HIGH-CAPACITY feeder drive for the handling of powders eliminates by its action troublesome arching and segregation of material and provides a continuous, uniform stream of free-flowing material at all times. The type 2520 feeder drive is a self-contained unit bolting directly to conveyor end and requiring no intermediate coupling. It has wide-babbitted and bronze-bushed bearings seating large-diameter drive shafts. An accurate and convenient speed-adjusting mechanism provides an even, continuous rate of discharge. Heavy steel-tipped pawls and wide nonslip ratchet wheel assure long life. Manufacturer: Sprout, Waldron & Co., Muncy, Pa.



For further information circle MD 29 on card Page 269

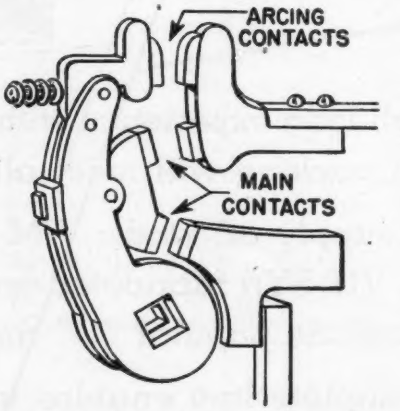
Welding Electrode

GENERAL-PURPOSE mild-steel welding electrode having good characteristics on direct-current straight, or reverse polarity as well as alternating current has been introduced by The Air Reduction Sales Co., 60 E. 42nd St., New York. The new electrode, known as No. 87, is especially recommended for low-cost single or multiple-pass welding on plates or sections where fit-up is poor or work is rusty or dirty.

For further information circle MD 30 on card Page 269

Precious-Metal Electrical Contacts

SILVER-MOLYBDENUM electrical contacts possessing excellent arc-resisting characteristics are available in special shapes made by the powder-metal process. New contact material is supplied in two grades: Gibsiloy M-10 and Gibsiloy M-12, the latter containing the higher percentage of molybdenum. Alloy M-12 is recommended for heavy duty circuit breakers where the high mechanical and electrical stresses are resisted by the highly refractory material. Alloy M-10 is used on smaller-size circuit breakers handling lower pressures. Excellent combination of conductivity and hardness is made possible by combining the two metals by the powder metal process. Grade M-10 has 50% of the conductivity of pure silver and a hardness of 75 Rockwell B, while Grade M-12 has 45% conductivity and a hardness of 85 Rockwell B. Units are furnished solder-backed for convenience in application. Manufacturer: Gibson Electric Co., 8355 Frankstown Ave., Pittsburgh 21.

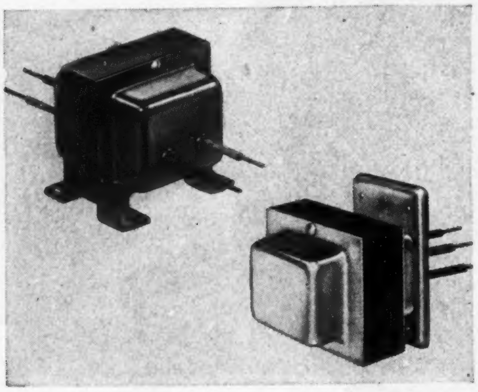


For further information circle MD 31 on card Page 269

Step-Down Transformers

COMPLETE NEW LINE of step-down transformers incorporates the two basic types: 115 volt to low voltage, and high-voltage to 115 volts. First type, for operating low-voltage devices, is available in either normal-reactance

series with 8, 16, 24 and 32-volt secondaries and capacities from 25 to 150 va; and high-reactance series with 25 and 30 volt secondaries and capacities of 20 to 80 va. Units are mounted either with standard shields and mounting feet or with outlet-box covers that fit standard round and octagonal boxes. Higher-voltage transformers will step 230, 460, or 575-volt power down to 115-volts. They are offered in capacities from 25 to 250 va with standard mounting feet for in-compartment wiring, or with rectangular outlet-box covers for mounting on FS or FD-type boxes. Units for heavy duty have capacities from ½ to 10 kva. Manufacturer: Chicago Transformer Division of Essex Wire Corp., 3501 Addison St., Chicago 18.



For further information circle MD 32 on card Page 269

Cable-Type Transformer

INPUT TRANSFORMER for use in coupling low-impedance microphones to standard high-impedance amplifier inputs has frequency response from 50 to 12,000 cps. It permits running microphone lines up to 5000 feet with practically no loss in output or frequency response. Manufacturer: Amperite Co., 561 Broadway, New York.

For further information circle MD 33 on card Page 269

Cup-Packing Expander

STRIP EXPANDER for leather cup packings maintains constant contact between packing seal lip and cylinder wall. Made of heat-treated beryllium-copper, the expander counteracts tendency of packing to recede from wall and permit fluid leakage, yet is resistant to corrosion from contact with brine, gasoline, alcohol and other liquids. The HPL Strip Expander is said not to increase friction or wear on the packings, inasmuch as it exerts only sufficient force to maintain a constant pressure between packing and wall. Standardized to fit any cup diameter 2 inch and over, expander is produced in strip form and is cut off to suit packing size. Manufacturer: HPL Manufacturing Co., 2013 E. 65th St., Cleveland 3.

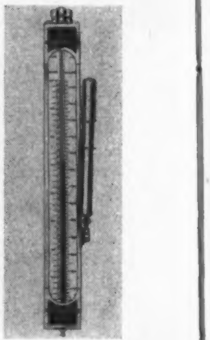
For further information circle MD 34 on card Page 269

Welding Electrode

DESIGNED for high-speed welding of grooved joints, positioned fillets and horizontal fillets, new DH-MO electrode is made in four diameters, from 5/32-inch to ¼-inch. It is suitable for welding low-alloy cast steel, or low-alloy high-tensile-strength rolled steels in the flat position with ac or dc straight polarity current. Manufacturer: Westinghouse Electric Corp., 306 Fourth Ave., Pittsburgh 30.

For further information circle MD 35 on card Page 269

Liquid-Level Gage



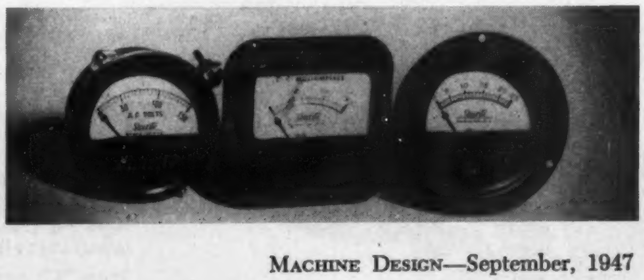
METER for remote indication of the liquid level in tanks will function whether tanks are open, vented, under pressure or under vacuum. Units can be furnished with high or low alarm switches for closing or opening any circuit at any predetermined high or low level. Fifty-two standard models are available for measuring liquid depths ranging from one ft to 75 ft and can be furnished for hand pump or compressed air operation. Manufacturer: Uehling Instrument Co., 473 Getty Ave., Paterson, N. J.

For further information circle MD 36 on card Page 269

Improved Panel Meters

LINE OF electrical panel meters in 2 and 2½-inch sizes is available in ac and dc ammeters, ac and dc milliammeters, ac and dc voltmeters and ohmmeters. The dc meters are of the polarized-vane type, while the ac meters are of the double-vane repulsion type. Both styles are accurate within 5 per cent. All models are of the flush-mounting type of black-enameled brass construction with mountings available in bracket, ring or screw styles with narrow or wide flanges optional. Zero adjusters are available on two of the dc types. Dials are metal, age and moisture resistant and lithographed in black and white for high visibility. Additional colors are supplied where required. Concealed coils, full-view scales and attractive styling and finish contribute to the modern appearance of the instruments. Manufacturer: Shurite Meters, 21 Hamilton St., New Haven 8, Conn.

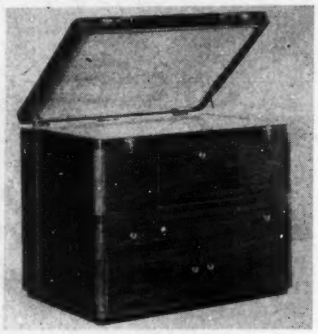
For further information circle MD 37 on card Page 269



engineering dept equipment

To obtain additional information on these new developments see Page 269

Contact Printer



VACUUM SEAL TYPE of contact printer has a usable printing area measuring 31 by 43 inches. The unit, known as the Vacuum Seal Portagraph Model G-112, is constructed with mortised and tenoned panel and has a rigid reinforced vacuum top. Unit contains a utility storage cabinet and a paper storage drawer and is equipped with an automatic electric timer for controlling the 25 and 65 watt lamps. It has a timer light to facilitate darkroom work and two ruby spotting lights. Vacuum pump of the element can create a pressure of 25 inches of mercury, sealing against a ⅛-inch rubber blanket mounted on edge of lid. Manufacturer is the Photo Records Division, Remington Rand Inc., 315 Fourth Ave., New York 10.

For further information circle MD 38 on card Page 269

Multi-color Mechanical Pencil

MECHANICAL pencil offers choice of six different colored leads by use of selector device on side of pencil. No larger than the ordinary mechanical types, the new instrument contains leads within the barrel from which they may be quickly selected by adjusting a metal clip attached to the pencil head. To prevent lead slippage, a novel three-section metal chuck holds the chosen lead firmly in writing position. Sight selection is afforded by small colored dots imbedded in instrument barrel. Manufacturer: Ross-Frederick Corp., Box 429, Mineola, N. Y.

For further information circle MD 39 on card Page 269

Resistance-Measuring Instrument

BRIDGE-MEG type of Megger combines in one unit a direct-reading ohmmeter for measuring insulation resistance and a wheatsone bridge circuit for measuring conductor resistance. Ohmmeter portion of unit is identical with standard Megger type of unit, and includes a hand-cranked generator to supply test current. Bridge circuit, which also draws current from the hand generator, will measure resistance from 0.01 ohm to 999,900 ohms with an error of one per cent or less, while the ohmmeter has a range up to 1000 megohms. Instrument measures 7 by 8 3/4 by 12 inches, and weighs 13 to 15½ pounds, according to the model. Manufacturer: James G. Biddle Co., 1316 Arch St. Philadelphia 7.

For further information circle MD 40 on card Page 269

High-Sensitivity Kilovoltmeters

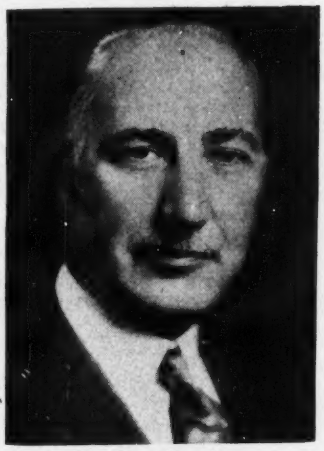
RECENTLY ANNOUNCED series of high sensitivity kilovoltmeters are specifically designed for measurements in television and similar electronic circuits. All of the instruments in this series are portable and feature little current drain in making high-voltage measurements. Typical unit, the No. 760-A kilovoltmeter has three scales —5, 10 and 20 kilovolts—with a sensitivity of 10,000 ohms per volt. The instrument thus draws only 100 microamperes at full scale. Scale selection is made by connecting leads to the proper insulated binding posts, while an-

other binding post provides ground connection. A polarity-reversing switch is supplied and provision is made for connecting an external meter where required. Multiplier sections are insulated from panels by high-grade ceramic insulators and accuracy is 2 per cent for dc measurements and 5 per cent for ac. Line of eight kilovoltmeters provides both dc and ac types in practically any required voltage combination. Manufacturer is the Shallcross Manufacturing Co., Collingdale, Pa.

For further information circle MD 41 on card Page 269

MEN . . . of machines

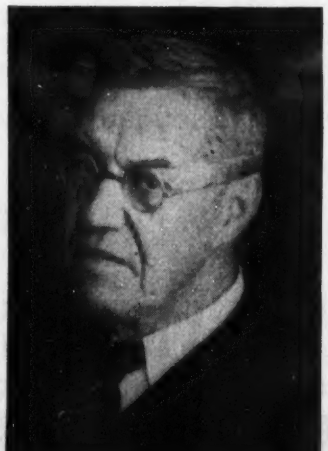
E. G. BAILEY, president-elect of The American Society of Mechanical Engineers for 1947-48, has been a vice president and director of The Babcock & Wilcox Co. since 1930. Mr. Bailey is also well known as the founder of the Bailey Meter Co., Cleveland, in 1916, and was its president until 1944 when he became chairman of the board. His many inventions, covered by more than 100 United States patents and numerous United States patent applications, include fluid meters, boiler meters, automatic combustion control and water-cooled furnace wall, pulverized coal feeders and burners, boilers and furnaces. He also is author of many papers on fuels, combustion and power developments. Mr. Bailey, who received his mechanical engineering degree from Ohio State University, also obtained other honorary degrees from this university, Lehigh University and Lafayette College. Numerous medals and awards were also given Mr. Bailey in recognition of his "achievement and leadership in steam and combustion engineering". Some of these include the Longstreth Medal of the Franklin Institute, one from ASME, the Percy Nicholls Award, and in 1936 the Lamme Medal from the Ohio State University.



E. G. Bailey

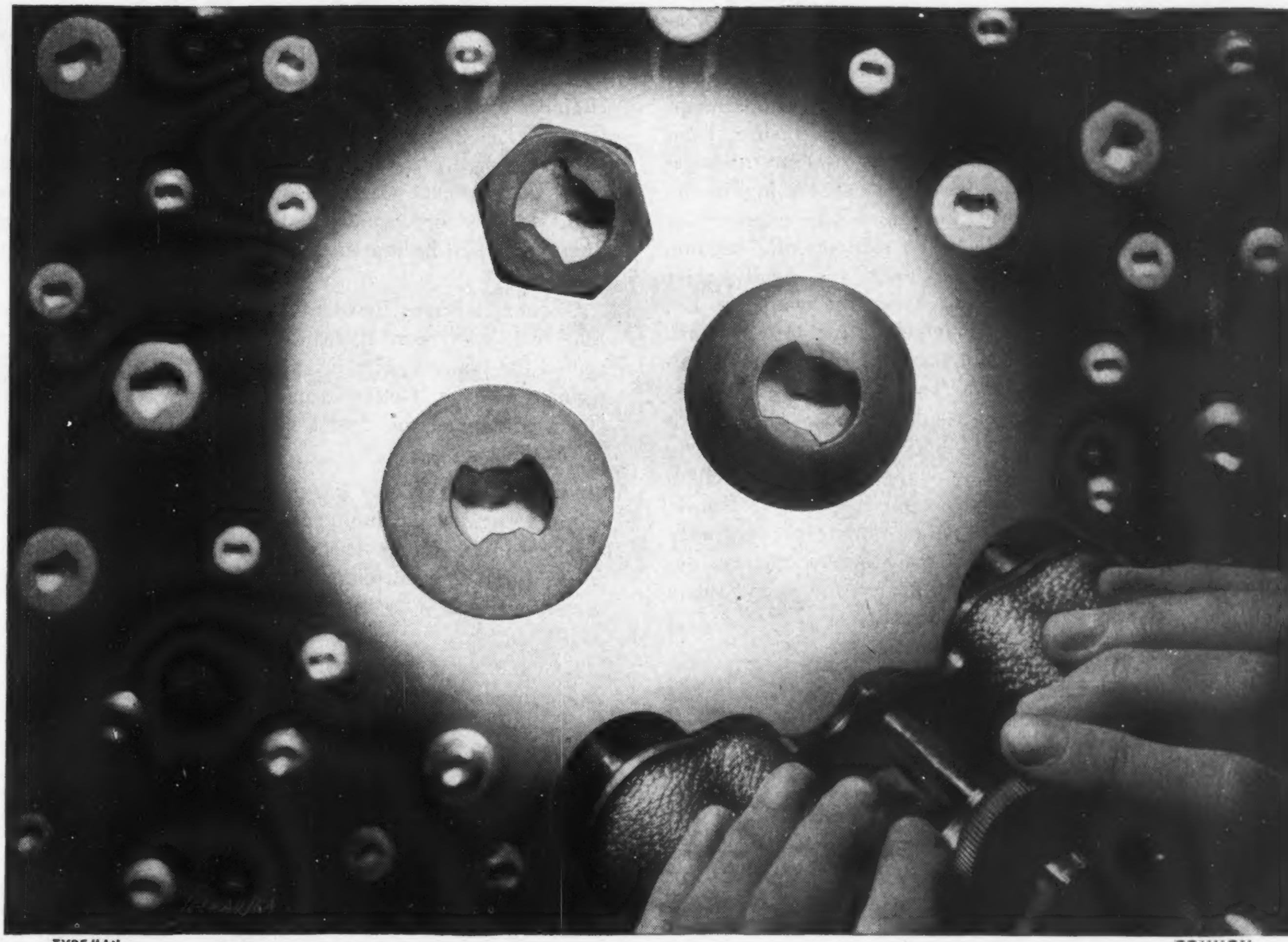
C. Richard Soderberg

C. RICHARD SODERBERG, deputy head of the department of mechanical engineering at the Massachusetts Institute of Technology and thus already thoroughly familiar with its administration, is ably fitted for his new appointment as head of this department. Professor Soderberg is widely known in the field of applied mechanics and internationally recognized as an authority on turbine design. Before coming to the institute in 1938, he had been manager of the turbine division of the Westinghouse Electric Corp. Professor Soderberg came to the United States from his native Sweden in 1919 on a fellowship and spent a year in advanced study of naval architecture at the Institute and at the University of Michigan, receiving a bachelor's degree from M.I.T. After a year on the technical staff of the New York Shipbuilding Corp., he joined the heavy traction railway department of Westinghouse and in 1924 was transferred to the power engineering department where he specialized on problems of large turbine generators. Later he returned to Sweden for two years to undertake development of large turbine generators for the Swedish General Electric Co., and when he came back in 1930 he joined Westinghouse again. From 1931 until his appointment at the institute in 1938, he was in charge of the turbine division. During the war Professor Soderberg served on the special committee on jet propulsion of the NACA, also on other government committees for the studies of tank design and evaluation of gas turbine power plants for ships. In addition to his government work, he also acted as a consultant.

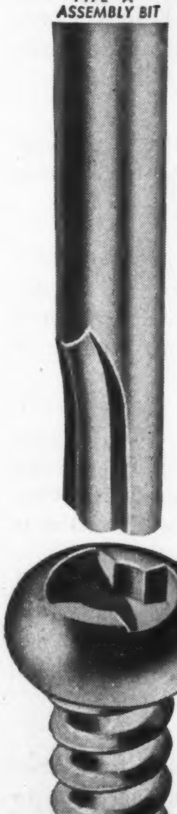


Vladimir L. Maleev

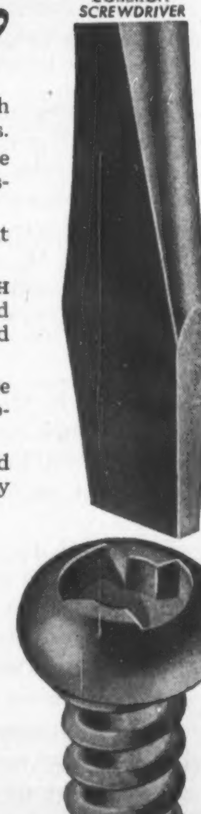
VLADIMIR L. MALEEV, who recently became associated with the University of Southern California as lecturer in mechanical engineering in the courses of machine design and design of internal combustion engines, is in a position to offer students the benefit of his forty-five years of experience in the theory and practice of machine design in a number of fields. These include diesel, gas, and gasoline engines, hoists, oil field machinery, transmission machinery, refrigeration and air conditioning. He resigned as consulting mechanical engineer with Harvey Machine Co. Inc., to accept this post. Before becoming connected with this or-



TYPE "A" ASSEMBLY BIT



COMMON SCREWDRIVER



What do you look for in a Screw?

IS IT HIGHER PRODUCTION? . . . The records of users credit CLUTCH HEAD with contributing 15% to 50% increases in comparison with all other screws.

IS IT SAFETY? . . . Users say dead-center entry with the Center Pivot column plus the deep definite torque grip eliminate driver canting and skidding; disposing of damage to manpower and materials.

IS IT SPEED? . . . High visibility of the roomy Clutch recess inspires confidence to cut out slow-down hesitation for a faster, smoother driving tempo.

IS IT EASIER DRIVING? . . . Operators testify that the all-square engagement of CLUTCH HEAD'S Type "A" Bit with the straight-walled recess eliminates need for fatiguing end pressure to combat "ride-out" as set up by tapered driving contact.

IS IT DURABLE BIT SERVICE? . . . Would you like to see the Type "A" Bit that drove 214,000 screws in continuous assembly operation for the largest automobile manufacturer in the world?

IS IT ONE-HANDED DRIVING? . . . The simple CLUTCH HEAD Lock-On unites screw and bit as a unit for reaching into hard-to-get-at spots . . . also for easy service withdrawal of screws located behind surrounding units.

Send for assortment of America's most modern screw, sample Type "A" Bit, and illustrated Brochure.

IS IT LOW TOOL COST?
This rugged Type "A" Bit may be repeatedly restored to its original efficiency by a 60-second application of the end surface to a grinding wheel. No delay. No expense.

CLUTCH HEAD SCREWS

IS IT SIMPLE FIELD SERVICE?
. . . CLUTCH HEAD is the only modern screw basically designed for operation with a common screwdriver, which need only be reasonably accurate in width.

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

ganization, he had been professor emeritus at the Oklahoma A & M College. He obtained a leave of absence for the duration of the war and became senior mechanical engineer (diesel) at the U.S.N. Engineering Experiment Station in Annapolis. Prior to his professorship, from 1931-1942, he had been chief engineer of Western-Enterprise Engine Co. His first position since coming to the United States in 1920 was that of design engineer of Western Machinery Co., where he subsequently became experimental and consulting engineer, and finally chief engineer. Before leaving Russia, where he was born, Dr. Maleev was president of the Polytechnic Institute of Omsk from 1917 to 1919. He obtained his mechanical engineering degree at the Imperial Technical College in Moscow in 1902 and became instructor at the St. Petersburg Polytechnic Institute from 1903 to 1906. From 1906 to 1917 he was associate profesor and professor of mechanical engineering at the Technological Institute of Tomsk. Dr. Maleev is well known as an author of over fifty manuals, books, papers on thermodynamics, theory, design, and testing of internal combustion engines and steam turbines, and also on technical education.

H .W. Rogers has relinquished his responsibilities as engineer of the paper and textile division to become engineering consultant in this division of General Electric, with special assigned duties. G. W. Knapp, formerly engineer, rubber and printing division, was appointed to the position formerly occupied by Mr. Rogers, while C. E. Miller, engineer in the rubber and printing division, was appointed to succeed Mr. Knapp.

A. H. Miles is the new chief engineer of The Steel Improvement & Forge Co., Cleveland.

Tony Reitberger has been appointed assistant chief engineer of Warren City Mfg. Co. Mr. Reitberger brings a wide knowledge of the metalworking industry to his new post, having been associated with press manufacturers for the past seventeen years. Immediately prior to his present appointment, Mr. Reitberger had been for ten years design engineer and engineering department head in charge of the heavy mechanical press division of Cleaning Machine Corp.

William C. McFadden, chief engineer since 1945, has been appointed director of planning for Pacific Airmotive Corp. He will be in charge of special machinery design, plant layout, etc.

Thomas H. Latimer will assume his new duties as executive engineer in charge of engineering, drafting and estimating for the John Waldron Corp. Prior to his new appointment, Mr. Latimer had been chief engineer of Black-Clawson Co., Hamilton, O.

T. A. Worcester, assistant manager of General Electric central station divisions, has retired after forty-two years of service with the company. S. B. Crary and W. J. McLachlan have been appointed assistant managers. Mr. Crary, has been with the company since 1927, and after taking the test course offered by the company, worked on analysis of power-system generation, transmission and utilization apparatus. For his work on synchronizing of motors, he received the Charles A. Coffin award in 1937. From 1941 until his present appointment, he has been an engineer of the analytical division. Mr. McLachlan joined General Electric in 1924, taking its test course. He was engaged in distribution system engineering until 1939 when he assumed charge of the apparatus-line sponsor section. In 1943 he was assigned engineer of the production division, where he remained until his recent appointment.

George L. Beers, assistant director of engineering of the RCA Victor Division, Radio Corp. of America, recently received the honorary degree of doctor of science from Gettysburg College, Gettysburg, Pa., where he received his electrical engineering degree in 1921.

Edward F. Cahoon has rejoined TelAutograph Corp. as chief engineer, assuming full responsibility for all technical activities and services, including engineering research and development on telescribing systems for instantaneous communications in writing.

Lawrence H. Bailey of the F. J. Stokes Machine Co., Philadelphia, has been awarded the Stevens Institute Medal for achievement in powder metallurgy.

Wilson H. Moriarty, vice president of National Malleable & Steel Castings Co., Cleveland, has been elected president of the Malleable Founders Society.

Paul Hovgard has been made general manager in charge of the engineering and factory divisions, and the inspection department of the Piasecki Helicopter Corp., Sharon Hill, Pa. Previously, Mr. Hovgard was an associate director of the Cornell Aeronautical Laboratory.

W. E. Higginbottom, formerly president of Package Specialties, has been named design engineer of Shumann Equipment Co., Pittsburgh.

Dr. Donald Babcock Keyes, director and vice president in charge of research and development of the Heyden Chemical Corp., New York, received an honorary degree of doctor of engineering from the Stevens Institute of Technology.

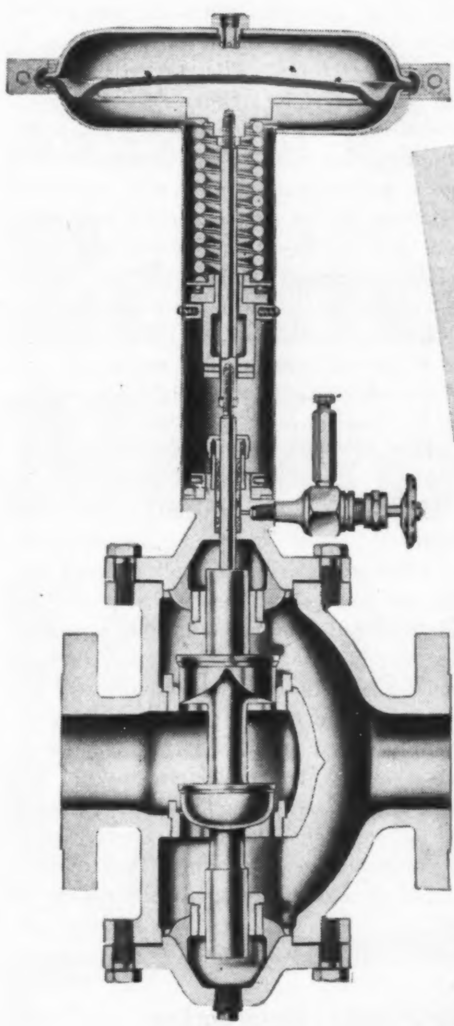
John W. Greve, managing editor of Machine Design, has been elected president of the Cleveland Engineering Society at its sixty-seventh annual meeting. This society has the distinction of being one of the oldest societies in the country.

Otto E. Kirchner, formerly director of research and development, American Airlines Inc., La Guardia Field, New York, has been made director of engineering at Tulsa, Okla.

Lloyd A. Cummings has been promoted from chief engineer to vice president and works manager of the Marlin Rockwell Corp. plants at Jamestown and Plainville, Conn. Daniel Gurney, formerly assistant chief engineer, replaces Mr. Cummings as chief engineer at the company's Jamestown, N. Y. plant.

Durable diaphragm for motor control valve made of NEOPRENE

Stands up under constant flexing . . . resists deterioration from heat and oil.



Valve manufactured by
Kieley & Mueller, Inc.
North Bergen, New Jersey

MOTOR CONTROL VALVES are used in many industrial processes where accurate control over the flow of liquids or gases is required. Key part of this type valve is the diaphragm . . . a thin, flexible membrane which is activated by air pressure to increase or decrease flow rate through the valve orifice.

In the Kieley & Mueller valve illustrated, a neoprene diaphragm with a fabric insert was specified. It has proved highly efficient under operating conditions . . . flexible and sensitive to slight pressure changes, yet tough and durable. It withstands constant flexing without cracking. Elevated temperature to which the valves are often exposed have little effect on neoprene. It resists deterioration from any entrained dirt and oil in the compressed air supply. And because of neoprene's low permeability, air pressure on the diaphragm can be held constant.

• • •

Design engineers have found Neoprene to be the answer when an elastic material for unusual service is required. The Neoprene Notebook contains articles on how others have utilized this versatile Du Pont rubber. We'll be glad to mail it to you. For your free subscription, write to: E. I. du Pont de Nemours & Co. (Inc.), Rubber Chemicals Division A-9, Wilmington 98, Del.

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- ★Special compositions are flame-retarding, static-conducting, flexible at low temperatures.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

DU PONT
REG. U. S. PAT. OFF.

Automatic Flight

(*Concluded from Page* 120)

shown from the geometry of *Fig.* 4 that the error V is equal to:

$$V=\frac{C\sin A\sin(B-\theta)-X\sin[180-(A+B)]}{\sin[180-(A+B)]}$$

When the numerator of this expression is zero the error is zero, hence the computer is required to produce continuously an error voltage equal to

$$C\sin A\sin(B-\theta)-X\sin[180-(A+B)]$$

Referring to *Fig.* 5, the term $C\sin A$ is obtained in the computer by applying an alternating current voltage proportional to C to the primary of a variable transformer, T-1, whose secondary is turned mechanically through an angle equal to A. The output of the secondary is proportional to the sine of the angle between the rotor and the stator, thus producing a voltage proportional to $C\sin A$.

This value is multiplied by $\sin(B-\theta)$, as required by the equation, by applying it to a variable transformer, T-2, whose secondary is turned mechanically through an angle equal to $(B-\theta)$.

The term $X\sin[180-(A+B)]$ is added, algebraically, to $C\sin A\sin(B-\theta)$ by placing the secondary of a variable transformer, T-3, in series with T-2. The secondary of T-3 is turned through an angle equal to $[180-(A+B)]$ to obtain the correct value on the secondary. This total voltage, then, is proportional to the error normal to the desired ground course, and is applied to the automatic approach coupling unit of the E-4 automatic pilot. The action of this voltage applied to the automatic pilot is similar to that of a pilot who follows a homing signal as displayed on a right-left indicator.

Furnishing Directional Information to Computer

In *Fig.* 6 is shown schematically the coupling arrangement of the automatic radio compass receivers and the flux-gate magnetic compass that are used to furnish shaft rotation of the transformers in the computer. The antenna loops of the radio compass receivers automatically point to the radio station to which they are tuned. Coupled mechanically to the loop of each receiver is a transmitter selsyn that operates through a receiver selsyn and amplifier to turn the motor through an angle equal to the angular direction of the radio station from the aircraft. Thus *ARN*-7 No. 1 operates to produce angle A and *ARN*-7 No. 2 to produce angle B. Thus there is directional information in the form of shaft rotation so that the rotors of the computer selsyns, *Fig.* 5, can be turned to satisfy the mathematical relationships required.

If the heading of the aircraft changes, the radio stations will appear to be in different directions, necessitating the azimuth stabilization of the servo system from information from the flux-gate magnetic compass. The receiver selsyn from the flux gate, *Fig.* 6, operates through amplifier No. 3 to turn the stators of the radio compass receiver selsyn through an angle equal to the heading of the aircraft with respect to true north. The output motors turn through angles A and B and are coupled to T-1, T-2, and T-3 as shown in *Fig.* 7. A differential gear adds the two angles A and B as required to apply them to the rotor of T-1.

As the aircraft progresses on its course, the continuous information from the radio compass receivers is used to turn the computer selsyn rotors, whose output is a voltage proportional to the course error. Changing of the constants in the computer for operation with successive pairs of radio stations is accomplished through the Master Sequence Selector which actuates automatic tuners for the radio compasses, and applies the different values of C, X, and θ at the correct times. The point of changeover from one pair of stations to another is sensed by a simple cam system on the rotors of the receiver selsyns, that completes the energizing circuit of the Selector when the aircraft reaches a preselected position with reference to the two radio stations in use in a particular sequence.

The systems described in the foregoing are typical of the units required in producing automatic flight. Other flight instruments, notably the APN-1, a radio altimeter used for altitude "sensing" and the SCS-51 blind landing beam system, are integrated into similar automatic systems to form the complete Automatic Flight Controller.

Far from being the final answer to all-weather flying, the Automatic Flight Controller must await the development of finer electronic instruments for completely foolproof operation. It has, however, demonstrated adequately that automatic flight can be accomplished. Engineers of the All-Weather Flying Division and Air Materiel Command are now set to the task of perfecting the Automatic Flight Controller for foolproof operation irrespective of the conditions that might be met. Although there have been many times when the "brain" was not adequate for safe control due to its inability to delineate ambiguous information given by the instruments, it is believed by those close to the development that the major obstacles in producing automatic flight have already been hurdled. The future then will disclose the extent to which engineering ingenuity can produce electronically the actions required to fly aircraft automatically during all weather conditions.

Twin-Rotor Helicopter

A captured German helicopter of unique design is nov undergoing tests to determine the validity of claims indicating radical improvements in engineering and performance. Distinguished by two intermeshing contrarotating two-bladed rotors, mounted so that the axis of each makes an angle of 24 degrees with that of the other, the helicopter is known as the Flettner 282. The right-hand rotor revolves clockwise and the left-hand counterclockwise, as viewed from the pilot's seat, this configuration being similar to the U. S. Army Air Forces' XR-8 experimental helicopter.

The intermeshing blades are claimed to eliminate torque, and the machine is described as "extremely maneuverable". It has been successfully flown by the Germans in heavy rain and wind storms under blind flight conditions, including a 95-hour endurance contest. It will climb 300 feet a minute, has a hovering ceiling of 1000 feet and has a maximum speed of 90 miles per hour.

Hydrostatic Lubrication

(Continued from Page 131)

per inch. Values of m range usually between 0.0005 and 0.003 inch per inch. Substituting for h, q becomes

$$q = -\frac{b\,m^3 r^3[1-c\cos\theta]^3}{12\,\mu}\,\frac{dp}{d\theta}$$

The volume flowing through the differential slot is the quantity displaced by the relative motion of journal and bearing. The amount forced out between the top and position θ, on one side, is

$$q_D = v\,b\,r\sin\theta$$

Equating q and q_D,

$$v\,b\,r\sin\theta = -\frac{b\,m^3 r^3[1-c\cos\theta]^3}{12\,\mu}\,\frac{dp}{d\theta}$$

$$dp = -\frac{12\,\mu\,v}{m^3 r}\,\frac{\sin\theta}{[1-c\cos\theta]^3}\,d\theta$$

Integrating to obtain an expression for p for any point on the circumference,

$$p = \frac{12\,\mu\,v}{m^3 r}\left[\frac{1}{2c(1-c\cos\theta)^2} + C\right]$$

The constant of integration can be evaluated from the physical boundary condition that $p = 0$ when $\theta = \pi/2$ (90 degrees), from which $C = -1/2c$ and

$$p = \frac{6\,\mu\,v}{m^3\,r\,c}\left[\frac{1}{(1-c\cos\theta)^2} - 1\right] \qquad (33)$$

The total load-carrying capacity can be evaluated by summing up the vertical components of the pressure along the length of the arc on which the pressure acts. Gumbel and Everling[3] have applied a numerical and graphical analysis to this problem and have obtained the load-carrying capacity of this type bearing for several values of eccentricity c. The problem, however, as demonstrated in this article, has now been solved explicitly for all values of eccentricity. Agreement with the results of Gumbel and Everling is excellent.

In *Fig.* 40 is shown the component of the force dW in the direction of translation produced by the oil pressure acting on a differential area of width $rd\theta$ and length b:

$$dW = b\,r\,d\theta\,p\cos\theta$$

and

$$W = 2\int_0^{\pi/2} b\,r\cos\theta\,d\theta\,\frac{6\,\mu\,v}{m^3\,r\,c}\left[\frac{1}{(1-c\cos\theta)^2} - 1\right]$$

$$= \frac{12\,\mu\,v\,b}{m^3 c}\int_0^{\pi/2}\left[\frac{\cos\theta\,d\theta}{(1-c\cos\theta)^2} - \cos\theta\,d\theta\right]$$

which on integration becomes

$$W = \frac{12\,\mu\,v\,b}{m^3 c}\left[\frac{\sin\theta}{[1-c^2][1-c\cos\theta]} + \frac{2c}{[1-c^2]^{3/2}}\tan^{-1}\left(\frac{\sqrt{1-c^2}}{1-c}\tan\frac{\theta}{2}\right) - \sin\theta\right]^{\pi/2}$$

and the total load-carrying capacity may be written

$$W = \frac{\mu\,v\,b}{m^3}[K] \qquad (34)$$

where

$$K = 12\left[\frac{2}{(1-c^2)^{3/2}}\tan^{-1}\frac{\sqrt{1-c^2}}{1-c} + \frac{c}{1-c^2}\right]$$

Values of K have been computed and are listed and plotted on *Fig.* 41 so that either the instantaneous load-carrying capacity can be evaluated in terms of velocity or the instantaneous velocity can be found for a given load and film thickness or its equivalent eccentricity.

It is not practical to set up an expression for the time required for the film to reduce from an initial value of h_1 to some final value h_2, as has been done previously. Instead, individual, instantaneous velocities are computed and plotted against film thickness or eccentricity and some form of graphical or numerical integration is used to evaluate an average velocity of approach for the journal in its bearing. In this manner the time required for the film to reach its lower limit can be estimated.

Although the derivation was developed with respect to a 180-degree bearing it can be used with little error on a flooded 360-degree bearing, providing the pressures in the load-carrying film are large compared to any negative pressure that might be created in the crown of the bearing, where the journal is moving away from the bearing. For normal ambient pressures the maximum vacuum obtainable in the crown would be numerically equal to atmospheric pressure or 14.7 psi. The actual vacuum, however, will be less than this.

Following example will show how these equations can be applied to the wrist pin of an internal-combustion engine, *Fig.* 35. Diameter of the pin is ⅞-in., diameter of the piston is 3¼ in., diametral clearance between rod bushing and pin is 0.0006-in., and length of bushing is 1¼ in. SAE 20 oil at 180 F fills the clearance space. Mean effective pressure during the power stroke produced by inertia and gas forces on the piston is 125 psi. It is required to estimate the time required for the clearance at the top of the bushing to change from 0.0003-in. to 0.00003-in., assuming that the effect of end leakage is of secondary importance, and to compare this with the length of time the pressure would be applied with the engine operating at 3000 rpm.

Force acting on piston and piston-pin bushing is equal to pressure times area of piston or

$$W = 125\times\frac{\pi(3.25)^2}{4} = 1037 \text{ lb}$$

Radial clearance = 0.0003-in. = mr, from which the clearance modulus is m = 0.0003/0.4375 = 0.000686. Viscosity of SAE 20 at 180 F is 70 Saybolt Seconds, from which (M. D., June, 1947, Page 112) kinematic viscosity = 12.8 centistokes, absolute viscosity = 10.78 centipoises

which, converted to reyns, is $\mu = 10.78 \times 1.45 \times 10^{-7} = 15.63 \times 10^{-7}$ reyns (lb-sec per sq in.).

At initial conditions, h_0 is 0.0003-in. The radial clearance mr is 0.0003-in., however, so that h_0/mr is 1 and from *Fig.* 41 K is 18.85. The instantaneous velocity of approach, from Equation 34, is then given by

$$W=\frac{\mu v b}{m^3}(K)$$

$$1037=\frac{15.63\times10^{-7}\times v\times1.25\times18.85}{(6.86\times10^{-4})^3}$$

$$v=0.00908 \text{ in. per sec}$$

Repeating this calculation for a succession of other values and plotting, the curve shown in *Fig.* 42 results. The average velocity can be obtained in a number of ways, and is about 0.0041 in. per sec. The time for the film to be reduced from 0.0003-in. to 0.00003-in. is then

$$t=\frac{0.0003-0.00003}{0.0041}=0.066 \text{ sec}$$

For an engine running at 3000 rpm the duration of the power stroke would be 0.01 seconds.

Evidently the time required to produce a film of 0.00003-in. between the pin and bushing is about seven times greater than the length of time the force is actually applied. If there is no interference with the pressure build-up in the film or in the recovery of the film before the next application of load, this hydrostatic cushioning effect should prevent metal-to-metal contact. Oil holes, grooves and reliefs should be located with this effect in mind. When properly designed the instantaneous load-carrying capacity of piston-pin type bearings, knuckle bearings, crossheads and other similar bearing surfaces can be very great. Relative sliding velocity can become momentarily zero without film breakdown if the hydrostatic cushioning phenomenon exhibited by the viscous film is allowed to function.

In the series on hydrostatic lubrication, of which this is the concluding article, many kinds of load-carrying devices have been discussed, demonstrating the ease with which the simple concepts of hydrostatics can be applied to machine design. Oil pad bearings, oil lifts, step bearings and oil cushions have been but representative examples and the potential field of application is extremely great. The ability to support a wide range of loads can be fortunately coupled with vanishingly small coefficients of friction. Where impact forces or loads of short duration are encountered hydrostatic lubrication may well provide the happy solution. It is felt that when the basic simplicity and ease of application of this principle is more widely recognized, the designer will make increasingly greater use of its capabilities. *(End of Series)*

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Arbor Press of Welded Design Is Stronger, Lighter, More Economical

By K. A. Ruger, President
Ruger Equipment Co., Inc., Cleveland 14, Ohio

FOLLOWING the modern trend in machine design, the new Ruger 10-ton portable hydraulic arbor press was designed for arc welded steel construction for two reasons: (1) because we have found arc welding is generally the most economical fabricating process; (2) to achieve the greatest strength from the least weight. The Ruger press can easily be moved from place to place by one man as the total weight is only about 100 lbs.

Fig. 1 shows the component parts. The plates are SAE 1020 mild steel, cut out on a flame-cutting machine guided by templates. The two side plates are braked to a 1⅛" offset so they are closer together at the top. The base angles are formed from ⅜" flat plate on a brake and the corners rounded on the flame-cutter. The cylinder cover is seamless steel tubing bored out to take the hydraulic cylinder.

The sides, angles, spacer plate and cylinder cover are assembled in a jig and tack-welded together. Nearly all welding is done in this jig, which is tilted to various positions for 100% downhand welding. Fig. 2 shows the cylinder cover being welded to the side plates.

Fig. 2. Welding cylinder cover to the side plates.

Maximum welding speed is obtained by using Lincoln "Fleetwelding" technique—single pass, deep penetration welds in downhand position. "Fleetweld 11" electrode is used because of its speed, penetration and smooth concave bead which requires little finishing.

The side plates are welded to the base angles with the jig at a 45° angle (Fig. 3) to make single-pass fillets. The spacer plate is welded to sides with 1" intermittent welds and the ends of the base angles are butt-welded to the sides. The press is then removed from the jig, turned upside down and the angles joined to bottoms of the side plates with deep groove butt welds.

The cylinder welds are then ground down flush with the sides, and the other welds cleaned with a grinder. The hydraulic pump assembly is installed and a 16-gauge sheet metal cylinder cap is welded on with "Fleetweld 7," which makes a convex bead for a neat, rounded appearance. Then the unit is painted and crated.

Fig. 4 shows the completed press. Its overall dimensions are: 23½" high, 11¼" wide and 20" long from front to back. The throat height is 11" and ram stroke is 6⅝". Ram automatically retracts to top position by a built-in counter balance.

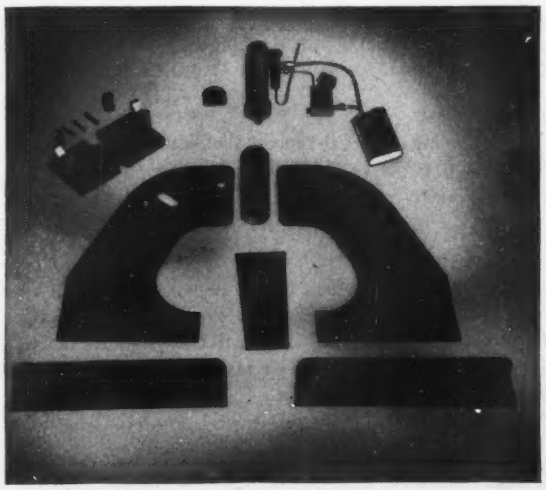

Fig. 1. Component parts of the Ruger Press.

Fig. 3. Welding base angles to side plates.

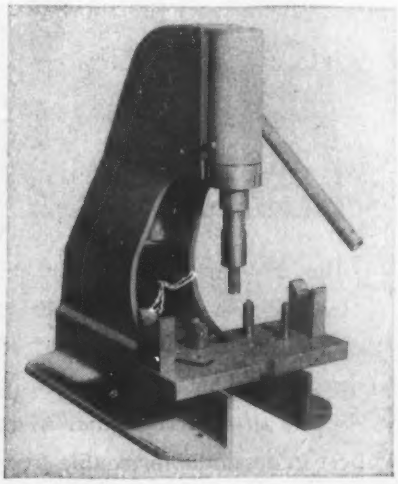

Fig. 4. The completed press.

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For Studies in Machine Design, write The Lincoln Electric Company, Dept. 356, Cleveland 1, Ohio.

BUSINESS AND SALES BRIEFS

A NEW division has been created by Spun Steel Corp., Canton, O., to develop and market spun steel products for the parent company, Automatic Products Corp., New York.

♦

Previously chief design and development engineer at Wilson Mechanical Instrument Co. Inc., David F. Sklar has formed the Kent Cliff Laboratories, Peekskill, N. Y. The new organization is available for consultation, development and the manufacture of hardness testing equipment and associated apparatus.

♦

Appointment of G. L. Pike, 10 Winnemere St., Malden 4, Mass., to serve as sales representative in all the New England states has been announced by Gibson Electric Co., Pittsburgh.

♦

Reliance Electric & Engineering Co., Cleveland, now occupies its plant in Ashtabula, O. This move frees space in the Cleveland plant for new experimental and engineering departments.

♦

With headquarters at 908 Stephenson Bldg., Detroit, J. C. Hurley has been named manager in charge of original equipment sales of The Aro Equipment Corp., Bryan, O. Mr. Hurley has been connected with the automotive and farm implement industries for sixteen years, serving in a technical and sales capacity covering all phases of lubricating equipment problems.

♦

Changes in the personnel of its district offices have been announced by SKF Industries Inc. They are: Appointment of Roy C. Norton Jr. as a field engineer in the Hartford, Conn., district office; transfer of I. J. Torkelson, field engineer, from Chicago to the branch at Milwaukee; and appointment of R. M. Parrish to the sales staff of the Portland, Ore., district office.

♦

Simmonds-Folkening Co., 20 North Wacker Drive, Chicago 6, has been named to serve as representative in the Chicago territory for Newark Wire Cloth Co.

♦

A New York branch office has been opened by Commercial Filters Corp. at Room 1501, 92 Liberty St., New York 6. James M. Morrison is New York district manager, assisted by Harold C. Corwin. Orders and inquiries should be directed to the New York office since the sales agency agreement with Messrs. King and Shepherd has been terminated.

♦

Recent appointments have been announced by Twin Disc Clutch Co., Racine, Wis. They are: C. F. Mohrbacher, assistant sales manager of the Racine Division; A. E. Young, district manager of the West Coast territory, including California; E. H. Bennett, district manager of the Eastern territory, with

headquarters in the Newark office; J. B. Jenkins, district manager of the Michigan territory, with headquarters in the new sales office in Detroit which will be opened shortly; P. G. Tyrrell, assistant district manager of the territory served by the new Los Angeles office; P. W. Wahler, assistant district manager of the territory served by the Seattle factory branch; and Wade A. Eskridge, assistant district manager of the mid-continent territory to take charge of operations in the Tulsa office. H. A. Davis, manager of the mid-continent territory, had shifted his headquarters from Tulsa to Dallas. W. L. Dixon will continue to be with the Newark office as consulting sales engineer.

♦

John F. Cunningham Jr. has been appointed manager of the J. P. Devine Mfg. Co. plant at Mt. Vernon, Ill., according to a recent announcement by H. K. Porter Co. Inc.

♦

Completion of a new plant at Pittsfield, Mass., has been announced by the chemical department of General Electric Co. This will double the company's capacity to produce magnesium oxide.

♦

Assistant sales manager for the past five years, Frank U. Hayes has been named sales manager of the Bullard Co., Bridgeport, Conn. He succeeds E. Payson Blanchard, who has been appointed director of sales. Mr. Blanchard will be in charge of general administrative sales policies while Mr. Hayes will be responsible for executive sales functions.

♦

Bingham Stamping Co., Toledo manufacturer of brake lever assemblies and other stamping products, has merged with Herbrand Corp., Fremont, O., maker of standard tools and special drop forged parts. Both the plants will continue in operation under the name of Bingham Stamping Co.

♦

Appointment of Wilber F. Pray as New York district manager has been announced by Askania Regulator Co. The office is located in the building of the parent company, General Precision Equipment Corp., at 92 Gold St., New York 11.

♦

Previously eastern district manager of Emerson Electric Mfg. Co., Robert O. Dehlendorf has joined the sales staff of Jack & Heintz Precision Industries Inc., Cleveland. He will serve as Eastern district sales manager of the electric motor division.

♦

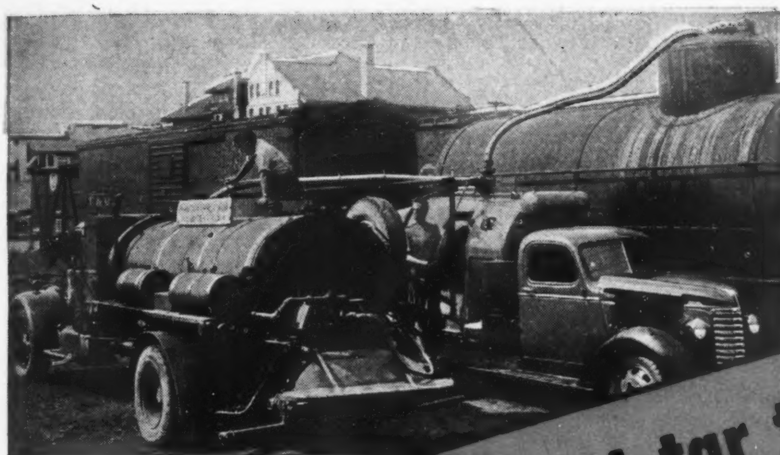
Wel-Met Co., Kent, O., subsidiary of S. K. Wellman Co., has been purchased by a group of Cleveland and Hudson business men. T. L. Robinson of Hudson is president of the new company; H. Leslie Kinney of Cleveland, executive vice president in charge of sales; and Leo R. Kuntz, Cleveland industrialist, secretary and treasurer. Sales headquarters have been established in Cleveland at West 58th St. and Walworth Ave.

♦

In charge of the New York branch office for the past twenty years, Richard M. Paxton Jr. has been elected a vice president of Jessop Steel Co., Washington, Pa.

♦

Changes in sales personnel have been made recently by Bethlehem Steel Co., Bethlehem, Pa. J. M. Ellis, formerly general manager of sales, has been appointed assistant to vice president. He is succeeded by K. L. Griffith, who formerly



American Steel Interlocked Flexible Tar and Asphalt Hose is here being used on tank car unloading equipment made by the Cleaver-Brooks Company of Milwaukee, Wisconsin. This type of hose is ideal for conveying hot tar and asphalt, since it is adapted to rough handling and is unaffected by the heat and chemical action involved in such use.

From pumping hot tar to shielding ignition systems

In the Glenn L. Martin Company's new "2-0-2" transport, American HTCD Shielding Conduit shields the ignition system and prevents interference with radio and radar operation. This conduit consists of an inner core of fully interlocked stainless steel flexible tubing, two layers of tinned copper wire braid and, finally, a molded synthetic cover for protection against moisture, dirt, dust and oil.

Flexible Metal Hose Performs Best

FOR A WIDE RANGE OF USES, such as transferring hot tar and asphalt, or shielding an airplane's ignition system to eliminate interference with radio and radar, there is a flexible product of American Metal Hose—specifically engineered for the job.

Wherever vibration, misalignment or connecting moving parts creates a problem in the conveyance of steam, oil, water and other liquids or gases, a most economical and efficient solution can usually be found in the American line:

American Metal Hose is available in brass, bronze, aluminum, steel, and other metals, some of these in sizes up to 12″ I.D.—made from strip in four spirally wound types. *American Seamless Flexible Metal Tubing,* as flexible as garden hose and as leakproof as the seamless bronze tube from which it is made, is standard in sizes 1/8″ to 4″ I.D. Either hose or tubing can be furnished complete with fittings to your exact specifications.

Descriptive literature will be mailed on request, and our Technical Department will be glad to help on exceptional problems.

47294

ANACONDA
from mine to consumer

American
METAL HOSE
THE AMERICAN BRASS COMPANY
American Metal Hose Branch
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: THE CANADIAN FAIRBANKS-MORSE CO., LTD., *Montreal 3, Canada*

was assistant general manager of sales. Mr. Griffith is succeeded in turn by D. C. Roscoe, who previously was manager of sales of sheets and strip. Replacing Mr. Roscoe is A. T. Hunt, who formerly was manager of sales of galvanized sheets and formed products. M. C. Schrader, assistant to the general manager, has been appointed assistant to the vice president.

♦

A central sales district with offices in Chicago has been formed by the technical products division of Corning Glass Works. John D. Brown, previously with the industrial sales department, has been appointed manager of the new district. Hugh Harris has been named manager of the Chicago office.

♦

Aluminum Co. of America, Pittsburgh 19, has announced the retirement of George J. Stanley as vice president and general sales manager. Succeeding him will be R. V. Davies, who formerly served as assistant general sales manager in charge of the company's sales engineering and sales development activities. Also announced are the promotions of Robert B. McKee and Donovan Wilmot from assistant general sales managers to vice presidents.

♦

With headquarters at 3701 North Broad St., Philadelphia, George E. Smith has been named to serve as a representative and engineer in the Middle Atlantic district for Kennametal Inc., Latrobe, Pa.

♦

John H. Biggs has been appointed Rochester representative of Brown & Sharpe of New York Inc. In his new position he succeeds Earl P. Leeds who joined the general sales staff at the Providence office of Brown & Sharpe Mfg. Co.

♦

Headquarters of Carbomatic Corp. are being removed from 117 West 63rd St., Manhattan, to a new plant at 24-S1 47th St., Long Island City, N. Y. Manufacturing and engineering facilities will be expanded, and an enlarged advisory service will be available to give effective guidance in the modern techniques of heat processing with infra-red. The company expects to maintain a branch sales office in Manhattan.

MEETINGS AND EXPOSITIONS

Sept. 17-18—

Society of Automotive Engineers Inc. Tractor meeting to be held at Hotel Schroeder, Milwaukee. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Sept. 17-26—

National Machine Tool Builders' Association. Machine tool show and congress to be held at Dodge-Chicago plant of the Tucker Corp., Chicago. Tell Berna, 10525 Carnegie Ave., Cleveland 6, is general manager of the association.

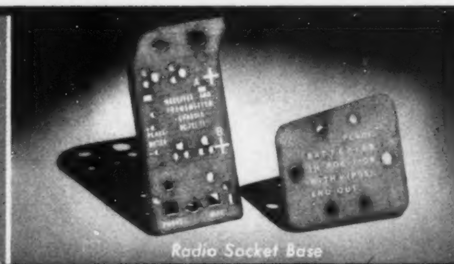
Oct. 2-4—

Society of Automotive Engineers Inc. Aeronautic (fall) meeting and aircraft engineering display to be held at Biltmore Hotel, Los Angeles. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

(Concluded on Page 200)

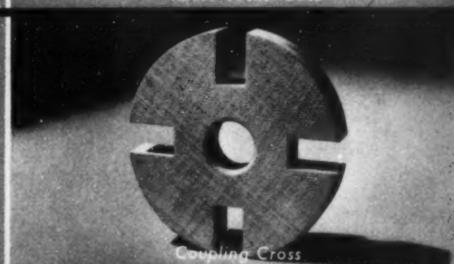
What'll You Have!

Dielectric? Synthane is an excellent electrical insulator. Dielectric strength is high, power factor and dielectric constant low. What makes Synthane the useful dielectric it is, is its strength and the comparative ease with which it can be punched or machined into the variety of parts needed on radio and electrical equipment.

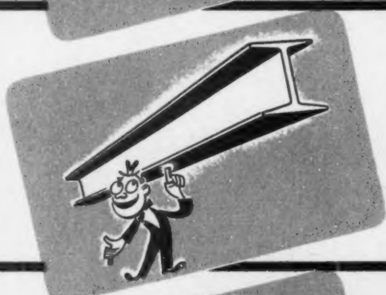


Radio Socket Base

Strength? Synthane seldom is asked to compete with metals and alloys in strength. It is exceptionally strong for its weight and will compare favorably with metals for strength on a weight basis. Synthane is a member of that family of plastics highest in tensile, compressive, flexural and impact strengths.



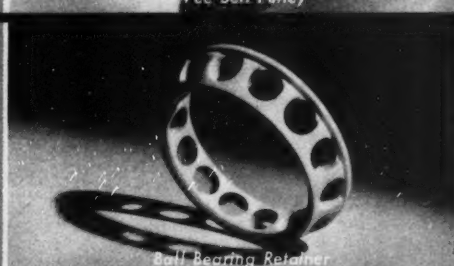
Coupling Cross



Light Weight? One of the most important properties of Synthane is its light weight. Although Synthane weighs only ½ as much as aluminum its strength is ample for electrical applications and sufficient for most mechanical uses. Light weight plus other virtues accounts for its wide use in aviation.

Vee Belt Pulley

Anti-friction? Two grades of Synthane laminated have anti-friction and anti-wear characteristics built in, due to the incorporation of a special graphite. Available in sheets, rods, tubes and in special shapes and fabricated parts. Possibilities for this material are worth investigating.



Ball Bearing Retainer

Corrosion Resistance? Perhaps you can take advantage of Synthane's immunity to most oils and solvents, Synthane's resistance to various concentrations of acids and salts. Often used because it has **longer life per dollar** than other materials, including cost of replacement.

Plating Tank Parts

Combination? Are you looking for two, three, four or even more properties combined in one material? Synthane may do the trick. It has all of the advantages above plus hardness, abrasion resistance, stability under temperature or moisture conditions, ease of machining, and many others.

Molded Gears

SYNTHANE CORPORATION, OAKS, PENNA.

Representatives in all principal cities

Plan your present and future products with Synthane Technical Plastics • Sheets Rods • Tubes • Fabricated Parts • Molded-laminated • Molded-macerated

SYNTHANE

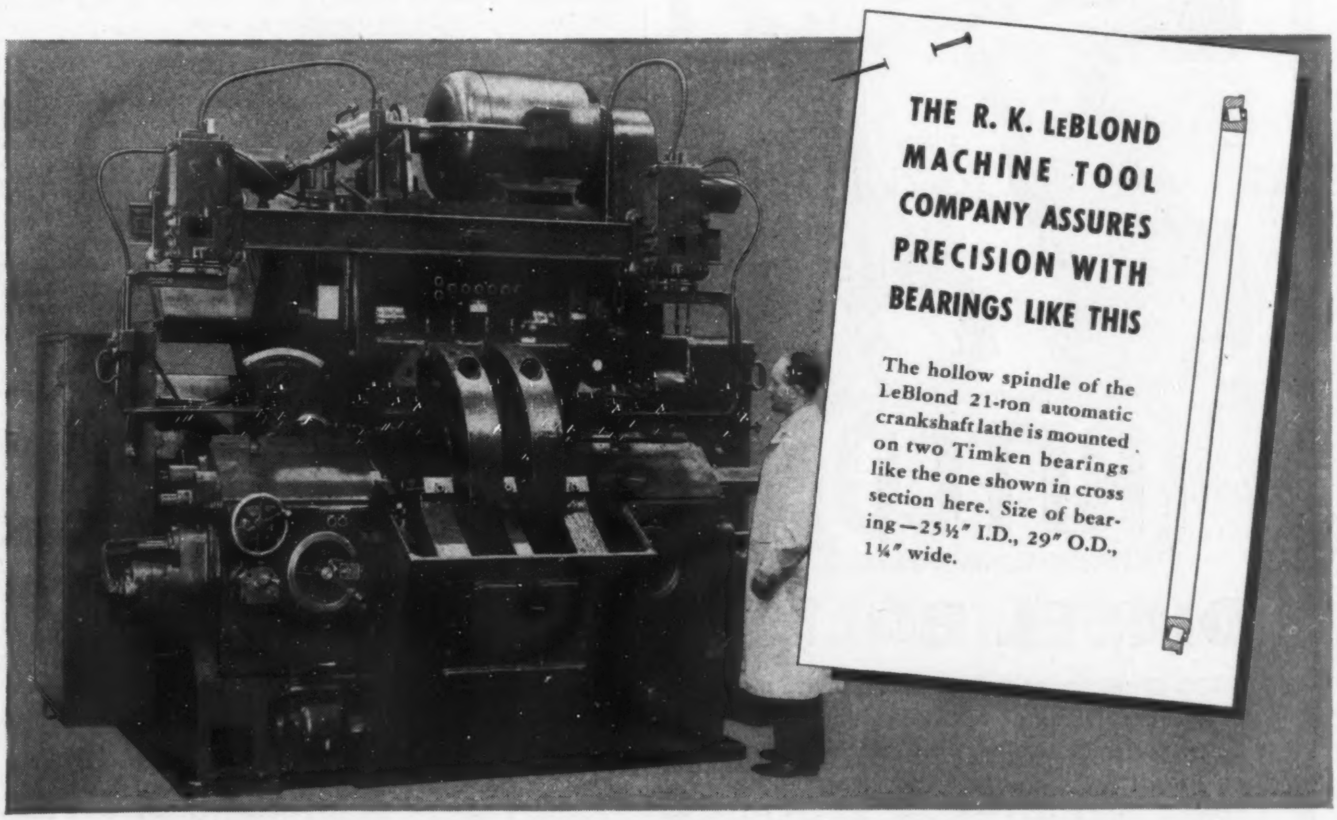
New 21-ton automatic crankshaft lathe relies on Timken bearings

PERFORMING fast, precision machining operations automatically on automobile crankshafts requires a high degree of spindle rigidity and accuracy. That's why in the 21-ton LeBlond automatic crankshaft lathe, the spindle is mounted on Timken tapered roller bearings.

Timken bearings may be preloaded to any desired degree to *keep* spindles accurate. The line contact between tapered rolls and races and the Timken fine alloy steel of which the bearings are made permit Timken bearings to carry heavy loads with minimum deformation and wear. Free, frictionless rotation is assured by true rolling motion, incredible smoothness of finish and precision manufacture. And the tapered construction of the Timken bearing carries both radial and thrust loads, or any combination of the two.

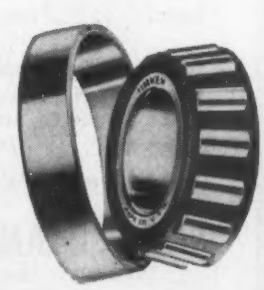
If the machine tools you buy or build can benefit from increased spindle rigidity and longer bearing life, get in touch with The Timken Roller Bearing Company. Because of unique design features and the fine alloy steel of which Timken bearings are made, no other bearing can give you as great a combination of advantages. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN BEARING EQUIPPED *This symbol on a product means its bearings are the best.*



See the TIMKEN EXHIBITS at the MACHINE TOOL SHOW
Spaces 317-D and 317-H
September 17-26

TIMKEN
TRADE MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS



NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

(*Concluded from Page 196*)

Oct. 6-7—

Packaging Machinery Manufacturers Institute. Fifteenth annual meeting to be held at Hotel Sheraton, Springfield, Mass. H. L. Stratton, 342 Madison Ave., New York 17, is secretary.

Oct. 6-8—

American Society of Mechanical Engineers. Petroleum mechanical engineering conference to be held at Houston, Tex. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York 18. C. E. Davis is secretary.

Oct. 18-24—

National Metal Exposition to be held at International Amphitheatre, Chicago. Chester L. Wells, 7301 Euclid Ave., Cleveland 3, is assistant managing director of the exposition.

Oct. 20-21—

Society of Automotive Engineers Inc. Production meeting to be held at Carter Hotel, Cleveland. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Oct. 20-22—

American Society of Mechanical Engineers. Joint meeting of the fuels division with the coal division of the American Institute of Mining and Metallurgcal Engineers to be held at Cincinnati, O. Additional information may be obtained from ASME headquarters at 29 West 39th St., New York 18. C. E. Davies is secretary of ASME.

Oct. 20-23—

American Institute of Mining and Metallurgical Engineers. Annual fall meeting of the iron and steel division and the institute of metals division to be held at Stevens Hotel, Chicago, in conjunction with the National Metal Exposition. Ernest Kirkendall, 29 West 39th St., New York 18, is secretary of the institute.

Oct. 20-24—

American Society for Metals. Annual meeting to be held at Palmer House, Chicago, in conjunction with the National Metal Exposition. W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, is secretary of the society.

Oct. 20-24—

American Welding Society. Annual meeting to be held at Sherman Hotel, Chicago, in conjunction with the National Metal Exposition. M. M. Kelly, 33 West 39th St., New York 18, is secretary of the society.

Oct. 20-24—

American Industrial Radium and X-Ray Society. Annual meeting to be held at Continental Hotel, Chicago, in conjunction with the National Metal Exposition. Philip D. Johnson, 53 West Jackson Blvd., Chicago 4, is secretary of the society.

Oct. 30-Nov. 1—

American Society of Tool Engineers. Fifteenth semiannual meeting to be held at Statler Hotel, Boston. Harry E. Conrad, 1666 Penobscot Bldg., Detroit 26, is executive secretary.

Nov. 3-5—

National Electronics Conference, sponsored by American Institute of Electrical Engineers and Institute of Radio Engineers, to be held at Edgewater Beach Hotel, Chicago. Additional information may be obtained from H. S. Renne, Publicity, Room 2114, 185 North Wabash Ave., Chicago 1.

Nov. 5-7—

American Society of Body Engineers Inc. Annual convention to be held at Rackham Memorial Bldg., Detroit. Otto Graebner, Murray Corp., Detroit, is secretary.

Nov. 6-7—

Society of Automotive Engineers Inc. Fuels and lubricants meeting to be held at Hotel Mayo, Tulsa, Okla. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Oct. 27-29—

American Gear Manufacturers Association. Semiannual meeting to be held at Edgewater Beach Hotel, Chicago 14. Newbold C. Goin, Empire Bldg., Pittsburgh 22, is executive secretary.

NOTE THE NORGRENS • AT THE SHOW *

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Of the Machine Tool Manufacturers exhibiting...

74.2% buy NORGREN PRODUCTS

74.2% are regular buyers of Norgren pneumatic equipment.

45.3% incorporate Norgren equipment as integral parts of their products.

EQUIPMENT THIS GOOD DESERVES YOUR EARLY ATTENTION

Ask our Design Engineer, at the Show (Booth No. 37A), how NORGREN *Lubricators, Lubro-Control units, Regulating Valves, filters* and other products create larger profits through *better performance, greater production* and *lower maintenance costs* of air-driven tools and cylinders.

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DENVER 9, COLORADO

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NEW TRANSPARENT BOWL FILTER

NEW MACHINES

And the Companies Behind Them

Air Conditioning

Automatic humidifiers to operate in conjunction with unit heaters. Humidify or discharge chemicals into air by atomization. Maid-O'-Mist Inc., Chicago.

Automotive

Two light battery chargers. Of selenium-rectifier type, charge in 24 hours or less. General Electric Co., Bridgeport 2, Conn.

Taximeter, small enough to fit into glove compartment. Glovebox Taximeter Corp., Houston 10.

Chemical

Tilting concentrator for concentration of fine sizes of heavy minerals, especially oxides, that are difficult to recover. Denver Equipment Co., Denver 17.

Multi-louvre dryer (or cooler) for materials requiring short time and/or multiple drying temperatures. Link-Belt Co., Chicago.

Metalworking

Special machine for milling tailpipe flange and intake manifold joint face on exhaust manifolds. Cross Co., Detroit.

Portable pipe thread machine. Cuts, reams and threads pipe of ½ to 2 in. in diameter. Larger sizes up to 8 in. may be handled with a special drive shaft. Century Engineering Co., Los Angeles.

Open-back inclinable presses with nonrepeat clutch mechanism insuring single-stroke operation. Federal Press Co., Elkhart, Ind.

Two-dimension follower mounted on a vertical lathe controlling cross and vertical movement of tool. Turchan Follower Machine Co., Detroit 4.

Hydraulic 10-ton assembly presses. Have maximum adjustable stroke of 12 in. and power stroke speed of 180 in. per min. with a return stroke of twice that amount. Colonial Broach Co., Detroit 13.

14-in. general-purpose, light-duty lathe. Has remote controlled belt shifting arrangement. Hendey Machine Co., Torrington, Conn.

Flexible shaft machine. Cabinet enclosed, the multispeed machine is available in five models. Wyzenbeck & Staff Inc., Chicago 22.

Two power saws equipped with automatic length gage for ⅛ to 48 in. Peerless Machine Co., Racine, Wis.

6-ton hydraulic press suitable for broaching and assembling, with steel work plate of 10 x 25 in. Acme Broach Corp., Lexington 47, Ky.

Special automatic tool grinder. Has two stations independently controlled. Length of grinding time can be predetermined. Ex-Cell-O Corp., Detroit.

Vertical precision cylinder boring machine, especially suitable for automotive engine blocks. Ex-Cell-O Corp., Detroit.

Grinder for small outside diameters, or irregular forms on small parts. Ex-Cell-O Corp., Detroit.

Fully automatic piston boring machine. Bores at rate of one piston every 30 seconds. Ex-Cell-O Corp., Detroit.

Precision thread grinder, hydraulically operated and electrically controlled. Adaptable to different types, sizes and forms of work. Ex-Cell-O Corp., Detroit.

Jig borer for holes up to 5 in. in mild steel or cast iron. Provides variable spindle speeds, pushbutton controlled, with a range from 90 to 2400 rpm. Moore Special Tool Co., Ann Arbor, Mich.

Electric powered, geared and hand-operated index tables in


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FABRICATION
Illustrated here is a typical Mahon Steel-Weld job produced for American's foremost Press manufacturer. Your heavy base and frame requirements, regardless of size, shape, weight or construction, can also be met more economically with welded steel. Highly specialized Mahon design engineers are your assurance of every advantage of Steel-Weld Fabrication . . . and, complete modern facilities, plus craftsmen who are masters in the welding art, will turn out a more accurate job, and a finer appearing job every time.
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Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products
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diameters up to 48 in. Buhr Machine Tool Co., Ann Arbor, Mich.

Two high-speed automatic screw and automatic cut-off machines. Also a larger automatic with 1 and 1½ in. capacity spindle. Brown & Sharpe Mfg. Co., Providence, R. I.

Bench-type, high-speed precision profile grinder, with work table having a 4-way tilt. Milwaukee Chaplet & Mfg. Co., Milwaukee 4.

Tapping machines containing a continuous flow lubricating pump. Procunier Safety Chuck Co., Chicago 6.

Fine pitch gear generating machine, for either spur or helical gears of smallest diameter to 3 in., over a 30 to 200 pitch range. Illinois Tool Works, Chicago.

60 in. x 60 in. x 20 ft capacity double housing, heavy-duty planers for rapid production. Liberty Planers Inc., Hamilton, O.

Automatic double end driller for crossed holes. Machine is hopper fed, drills, reams, countersinks and checks at desired angles. Has eight working stations and a loading and unloading station. Buhr Machine Tool Co., Ann Arbor, Mich.

High-speed inclinable hydraulic press with pressures up to 50 tons, and up to 100 strokes per minute. Hydraulic Press Mfg. Co., Mount Gilead, O.

Production bench tapper with selective full automatic cycle or hand operation with safety clutch. Tap diameters from No. 4 to 5/16 in. in cast iron, or ¼ in. in steel. Buhr Machine Tool Co., Ann Arbor, Mich.

Double-end low-swing lathe equipped with automatic loader for turning valve guides. Seneca Falls Machine Co., Seneca Falls, N. Y.

Wet model horizontal band saw, with 10 x 18 in. capacity. Johnson Mfg. Corp., New York 17.

Cam feed machines for mass production of small parts. National Automatic Tool Co., Richmond, Ind.

Spindle machine with complete electronic controls and four-way bed. Lucas Machine Tool Co., Cleveland.

High-speed grinder in both pedestal and mounted types. Has ¼-hp special torque motor delivering 18,000 rpm. R. G. Haskins Co., Chicago 12.

Precision surface grinder. Has combination finger tip control and automatic power feeds. Direct coupled hydraulic cylinder powers table movement. DoAll Co., Des Plaines, Ill.

Vertical milling machine. Three spindles provided for milling two top pads of clutch housing, two of which are mounted with interlocking cutters. Davis & Thompson Co., Milwaukee 14.

Special automatic drilling machine for truck rear-axle housings. Performs in a single automatic cycle a number of drilling operations. Snyder Tool & Engrg. Co., Detroit.

Small multidrilling and tapping machines. Models provide hand and foot feed or combination hand and foot feed and air-oil feed, also air feed. Spindle arrangement may be changed. National Automatic Tool Co. Inc., Richmond, Ind.

Pivoted blade shear capable of cutting 12 ft of ¾-in. steel plate, at 30 strokes per minute. Has 36-in. throat. Cleveland Crane & Engineering Co., Wickliffe, O.

Two hydraulic grinders: External and internal types. Both equipped with two heads to make a combination external-internal grinder, grinding work up to full swing over table of 9-in. diameter. The Greenby Mfg. Co., Plainville, Conn.

Back-geared 31-ton punch press. Bed area is 13 x 22 in. Stroke is 3 in., although shorter or longer strokes are available. Diamond Machine Tool Co., Las Angeles.

25-ton hydraulic press for pressing, straightening, bending, flattening, broaching, assembling, etc. Manco Products Co., York, Pa.


GRAPHITAR
(CARBON-GRAPHITE)
keeps
operating smoothly
THE UNITED STATES GRAPHITE COMPANY • SAGINAW,


Twin Disc Clutch Company uses
Graphitar Seal Ring to prevent leakage
Marine engines, road rollers, material handling equipment, conveyors, oil well drilling rigs, midget automobiles . . . these and many other mechanisms are now being operated with *greater efficiency, smoothness, and increased power*, thanks to Twin Disc Clutch Co. and Graphitar. Twin Disc manufactures hydraulic drive units in 1 to 300 HP models. Installed, as illustrated, in the Twin Disc Small Hydraulic Coupling (1 to 25 HP), the *Graphitar* seal assures a *long-lasting close fit*, because it is unusually resistant to wear, warp, chemical attack . . . and its dimensional stability is not affected by temperature extremes.
hydraulic power unit
and dependably
Graphitar seals, cylinder liners, bearings, vanes, and other parts are improving the efficiency of scores of mechanisms, because of Graphitar's *many unusual characteristics*. It is self-lubricating, chemically inert, and mechanically strong. It will not melt or fuse at any temperature. *It is featherweight*. We are equipped to mold Graphitar to any practical shape and size and to finish parts to tolerances as close as .0005" in small sizes. Send us sketches of your products and our engineers may show you where Graphitar parts will improve mechanical efficiency and save you money. *Ask for 44-page catalog.*
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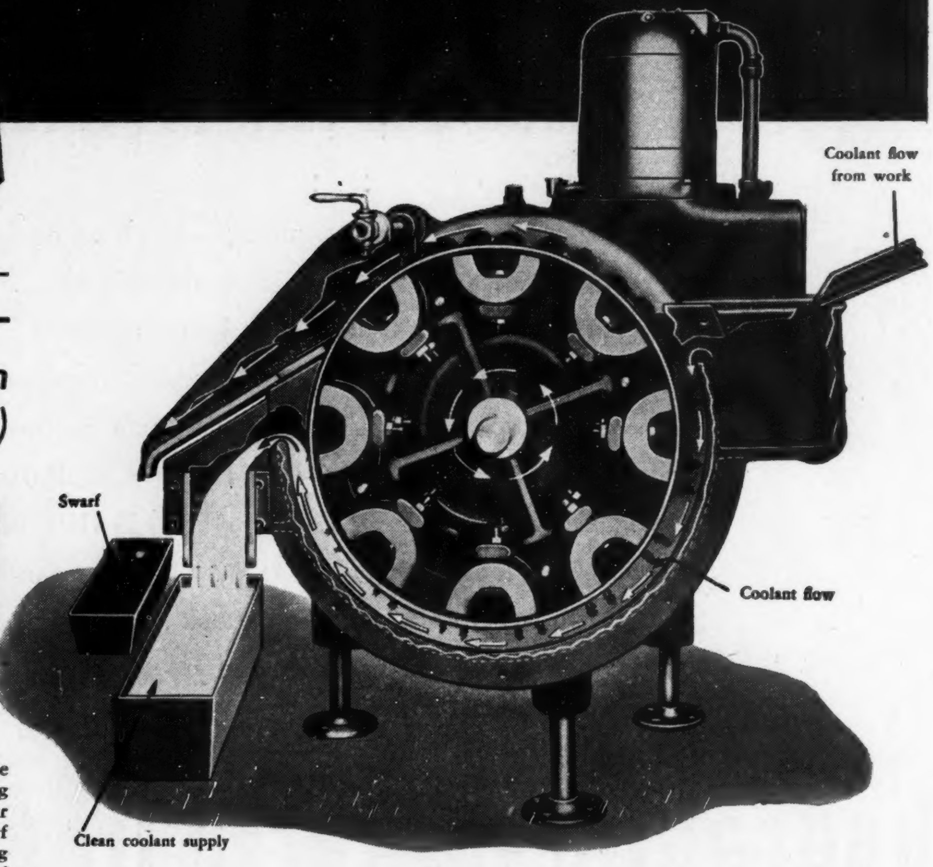
Cutting Oils Re-claimed Automatically...

with the help of...

ALNICO · MAGNETS

(Aluminum-
NICKEL—
Cobalt—Iron
Alloy)



BARNESDRIL AUTOMATIC MAGNETIC COOLANT SEPARATOR . . . pictured to show operation. Coolant from the work flows, as pictured, around a revolving drum that carries Alnico magnets on its inner face. On its outer face, the magnetic swarf fastens endwise over each magnet. Traveling with the drum toward a scraper, the swarf fine-combs most of the other entrained non-magnetic particles from the coolant. Standard sizes handle 5, 10, 20, 40 or 100 gal. per min.

Here's an open view of a separator that completely frees machine operators from the task of keeping coolants clean.

Fully automatic, this type reclaims as much as 100 gallons of oil per minute.

Developed and produced by Barnes Drill Co. of Rockford, Ill., the equipment incorporates a series of Alnico permanent magnets containing 20 per cent Nickel, which contribute fundamentally to the unique efficiency of this separator.

The exceptionally high magnetic properties of Alnico, an aluminum-Nickel-cobalt-iron alloy, permit designs that were technically impossible with older materials. Compared with the latter, Alnico reduces space and weight requirements to practical limits.

Nickel, an essential element in Alnico, also improves hundreds of other alloys for applications in the machine tool industry.

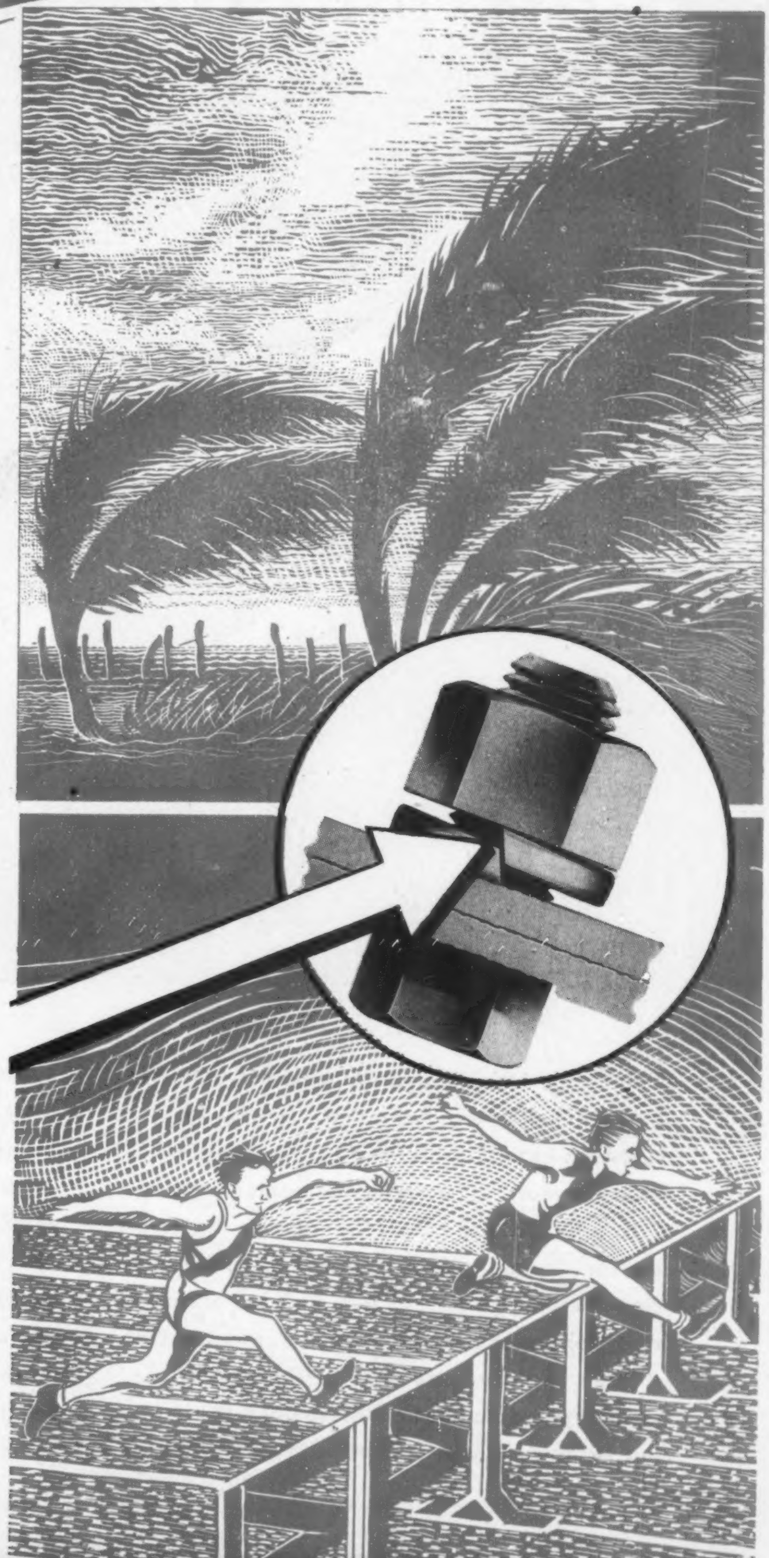
We invite consultation on the use of Nickel or Nickel alloys in your products or equipment.

EMBLEM OF INCO SERVICE
TRADE MARK

Over the years, International Nickel has accumulated a fund of useful information on the selection, fabrication, treatment and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes and other alloys containing Nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

The SPRING IS THE SECRET



–WITH TREES
–WITH MEN
–WITH ALL
BOLTED ASSEMBLIES

Unless trees were natural springs, every high wind would snap them off.

Unless your body had plenty of spring action, you'd jounce yourself to an early death—jumping, running or even walking.

Unless your bolted assemblies have spring action they'll inevitably jounce and wear themselves loose. The spring in Kantlink spring washers eases all shocks and all wear. It's the spring that compensates for initial looseness caused not only by wear of metal on metal, but by bolt stretch, by rust, flares, etc.

A tight nut, even though it never turns a hair on the bolt, is not enough to stop the other parts from wearing loose

You must use a spring—there is no substitute.

For real bolted security specify Kantlinks.

Send today for descriptive folders.

Originators of

KANTLINK

the long-range spring washer

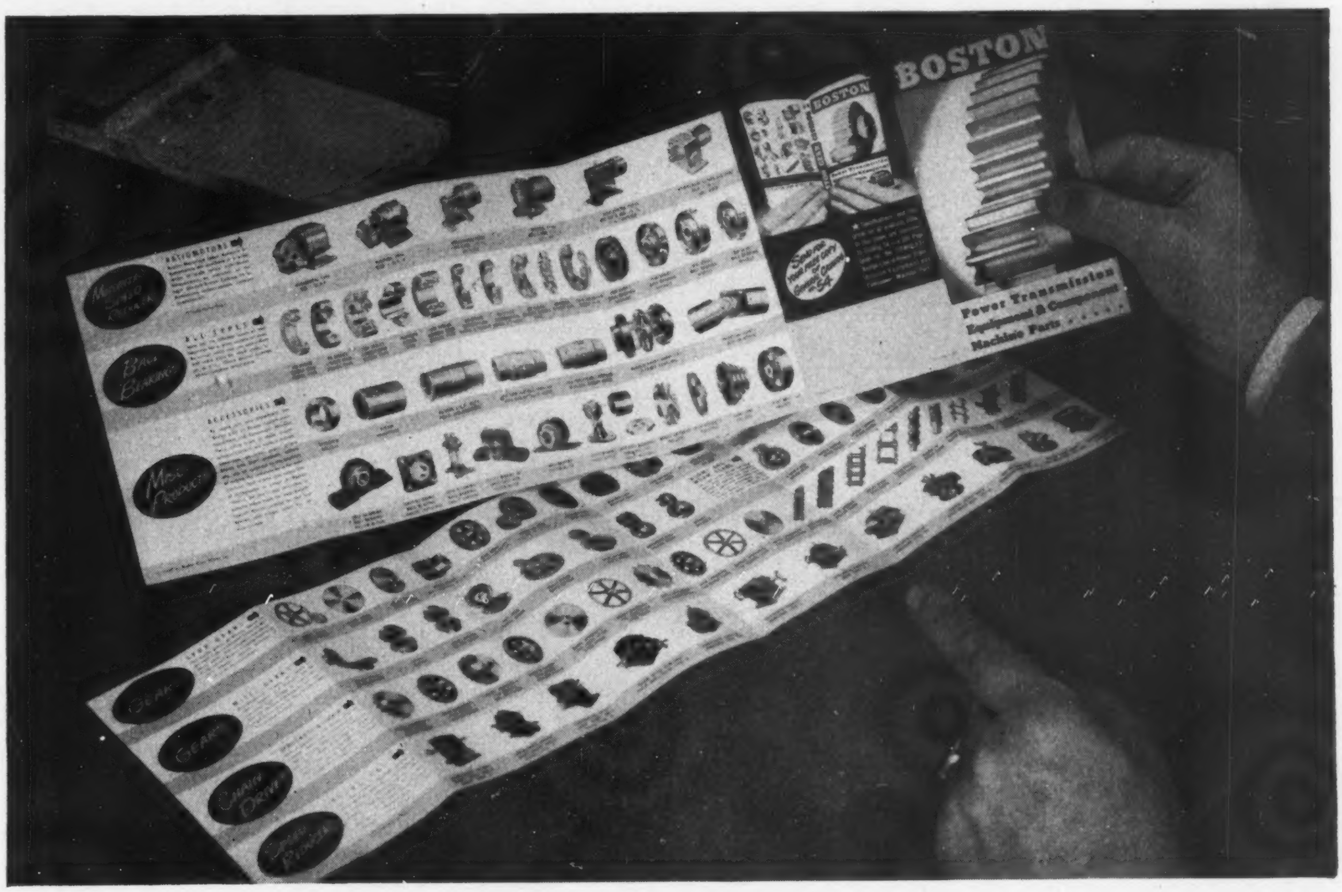
Made to accord with the new A S A specifications

THE NATIONAL LOCK WASHER COMPANY

Newark 5, New Jersey — Milwaukee 2, Wisconsin

One of the most complete lines I've seen!

The BOSTON line of power transmission equipment and component machine parts gives you one of the widest selections of stock products for the mechanical transmission of power. Consisting of four main divisions — GEARS — SPEED REDUCERS — CHAIN and SPROCKETS — and ALLIED ACCESSORIES — the complete BOSTON line has 101 individual groups of products available in over 4000 stock sizes. Sixty-two distributors carry large stocks of BOSTON Products. Send for your copy of New Folder No. 2-47 and complete list of stocking distributors.



101 SELECT FROM 101 INDIVIDUAL GROUPS OF PRODUCTS

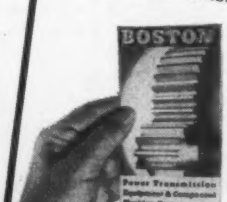
There are 101 groups of products in the BOSTON line — from various types of gears, speed reduction units and chain drives to couplings, pillow blocks, universal joints, ball bearings, pulleys, etc. Select your requirements from over 4000 stock sizes.

62 ORDER FROM 62 DISTRIBUTORS "COAST TO COAST"

For your convenience 62 distributors carrying stocks of BOSTON Products are located throughout the United States and Canada. Simply order BOSTON Products by catalog number and buy from your nearest distributor.

BOSTON GEAR WORKS, INC., NORTH QUINCY 71, MASS.

Please send me .... copies of your New Folder No. 2-47, illustrating your 101 Groups of Products. Also send me your complete list of 62 stocking distributors:



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STREET____________________

CITY__________ZONE____STATE______

BOSTON GEAR WORKS INC.

NORTH QUINCY 71, MASS.

Never..

LET "X" = AN UNKNOWN QUANTITY

WHEN you draw the familiar "X" symbol to indicate a valve in plans for any product involving fluid control, *never* let it represent a valve of uncertain performance.

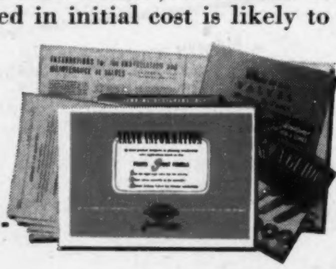
If you don't *know* it to be a top-quality valve, of the right pattern, properly placed in the assembly, you're inviting trouble that may give your whole product a "black eye". Second-rate valves only *seem* more economical, for the few cents saved in initial cost is likely to be paid out many times over in excessive servicing costs.

You can be sure of trouble-free performance when the "X" represents a Jenkins Valve. There's no better valve made. And, proper selection and application for faultless service is assured because you command the knowledge of Jenkins Engineers.

Equally important, your customers will be sure they are getting trouble-free valves when they see the familiar Jenkins Diamond trade mark. Your customers *know* Jenkins Valves . . . know them as tops in quality. You benefit from Jenkins leadership in advertising and consistent leadership in quality for 83 years. To your prospects Jenkins Valves will signify thoroughgoing quality construction throughout your product.

When planning new products, or redesigning present equipment that requires valves, — give your product, and its purchasers, the *extra value* of Jenkins Valves . . . *it costs no more.*

Jenkins Bros., 80 White Street, New York 13; Bridgeport, Conn.; Atlanta; Boston; Philadelphia; Chicago; San Francisco. Jenkins Bros., Ltd., Montreal.



GET JENKINS DESIGNERS' KIT. A handy file of valve information needed by product development men . . . helps answer the question — *"Which type of valve where for best performance?"* Mail the coupon.

JENKINS BROS., 80 White St., New York 13

Please send me the Jenkins Designers' Kit.

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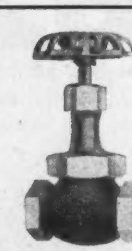
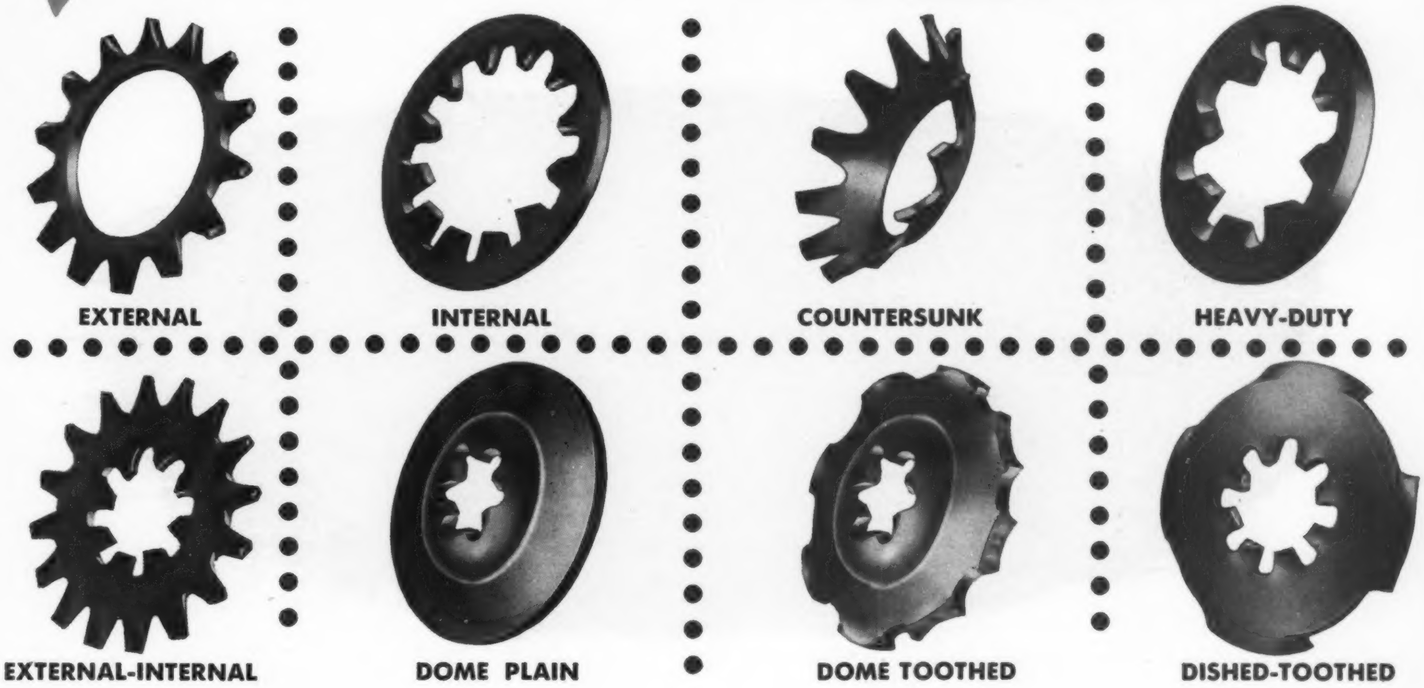
JENKINS VALVES



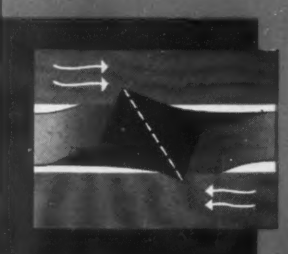
Types, Sizes, Pressures, Metals for Every Need

THERE'S A SHAKEPROOF LOCK WASHER

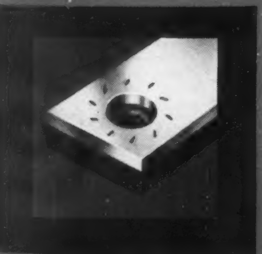
FOR EVERY *Locking* NEED



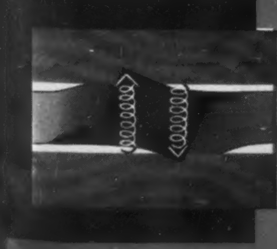
YOU GET THE FAMOUS SHAKEPROOF TRIPLE-ACTION PERFORMANCE



STRUT ACTION
Each tapered-twisted tooth bites into both surfaces, setting up a strut-action which resists all backward movement of nut or screw.



LINE BITE
The exclusive design of the tapered-twisted teeth assures a substantial line bite at initial contact, immediately producing a positive lock.



SPRING TENSION
As vibration begins, the spring tension of the teeth forces them to bite deeper, maintaining an absolutely tight lock.

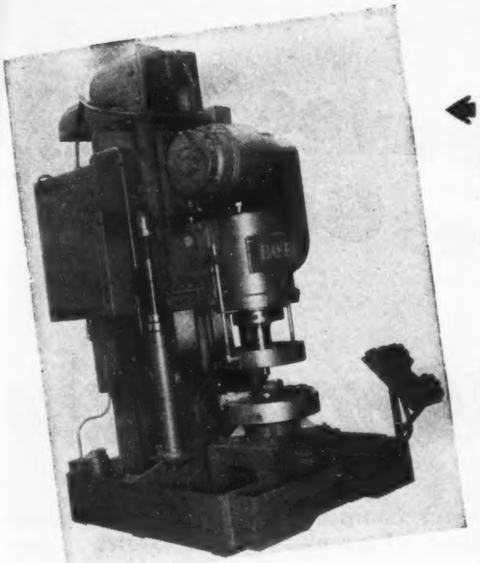
No matter what your fastening problem may be . . . oversize or elongated holes, hardened or soft materials, large or delicate parts . . . there is a Shakeproof Lock Washer designed to make your fastenings secure against vibration . . . to do your job at peak efficiency. And no matter what size or type you choose for your application, every Shakeproof Lock Washer incorporates the exclusive triple-action Shakeproof tapered-twisted teeth that actually bite deeper, hold tighter as vibration increases.

Shakeproof Field Engineers can be of great service to you in selecting the right size and type of standard washer, and their knowledge is especially helpful in the selection of one or more of Shakeproof's hundreds of specials that provide even greater fastening performance for specific problems than the standard types. When you meet fastening problems let a Shakeproof engineer meet *you!* A phone or written request will bring him to your plant! Call today.

SHAKEPROOF inc.
"Fastening Headquarters"

Plants at Chicago and Elgin, Illinois • In Canada:
Canada Illinois Tools Ltd., Toronto, Ontario

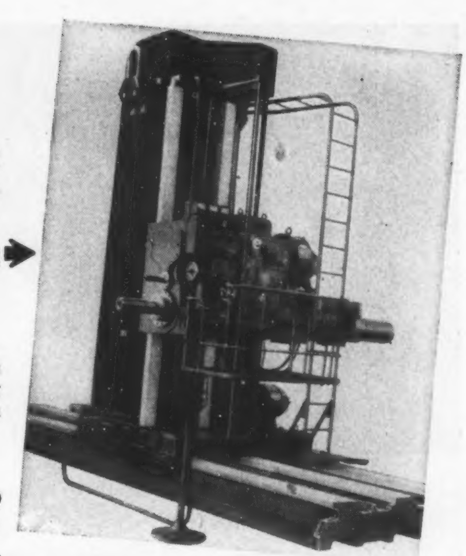
Division of ILLINOIS TOOL WORKS • 2501 No. Keeler Ave., Chicago 39, Ill.
Offices in Principal Cities



BAKER BROTHERS 40 HP BORING & DRILLING MACHINE. Booth No. 639

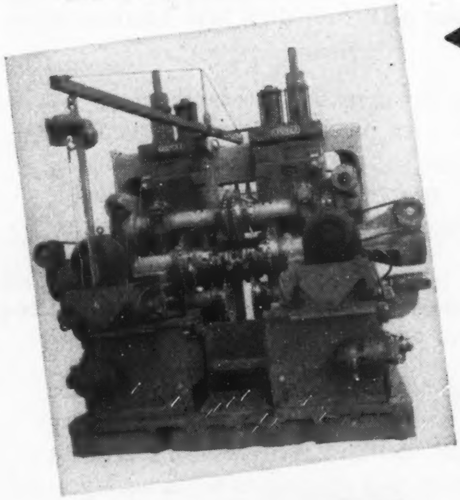
Cone-Drive to the spindle "gives powerful but smooth transfer of power" to the CARBIDE tipped multiple blade cutter head.

GIDDINGS & LEWIS MACHINE TOOL CO.'S BORING, DRILLING & MILLING MACHINE. Booth No. 315



Cone-Drives are used on this as well as other G & L machines for smooth, accurate transfer of power in less space than otherwise possible.

GISHOLT MACHINE COMPANY'S 50-TON 180-HP TURN MILL. Booth No. 304



Roughs all rod bearings on a crankshaft from the forging every 2 minutes. The six 24" OD—78 rpm cutters are individually driven from 25 hp motors through 25:1, 10" C.D. Cone-Drives at 445 SFPM. This drive not only transmits high power smoothly but saves considerable space. Two 4" and two 5" C.D. (No. 7415) Cone-Drives rotate the work spindle smoothly at 1 rpm. The 5" Cone-Drives are driven by 2 pinions, one on each side of the gear, arranged so as to eliminate backlash.

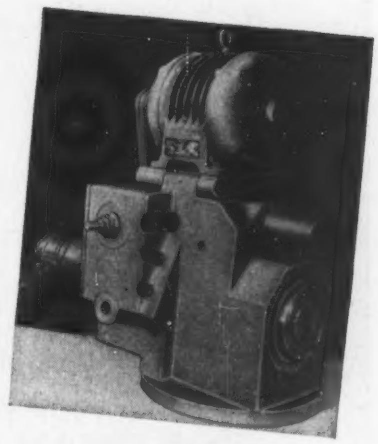
G. A. GRAY CO.'S 36 TON HORIZONTAL BORING, DRILLING & MILLING MACHINE. Booth No. 501

7½" C.D. Cone-Drives feed the column smoothly along the runway at ½" to 120" per minute to a micro-jogging accuracy of 0.00025". Gears are self-locking for climb milling conditions, make for compactness by saving space.

MICHIGAN TOOL'S NEW "3-WAY" UNDERPASS GEAR FINISHER. Booth No. 426

Faster gear finishing by *any* of 3 methods (selected at will) plus of course real smoothness and accuracy through Cone-Drives to the high speed cutters.

SHEFFIELD CORPORATION'S GEAR CHAMFERING MACHINES. Booth No. 202



With Cone-Drive geared heads "for greater accuracy, less chance of backlash, more tooth-to-tooth contact and higher gear strength."

See them at the Machine Tool Show

plus numerous other new Cone-Drive operated machines (photos not available at press time).

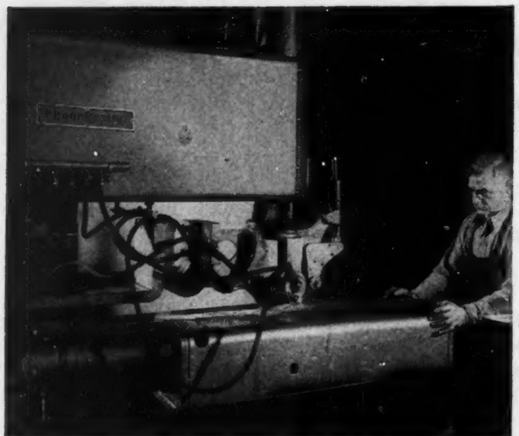
CONE-DRIVE

CONE-DRIVE DIVISION

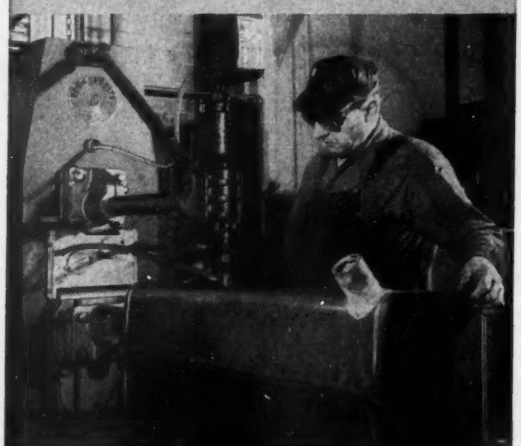
MICHIGAN TOOL COMPANY
7171 E. McNichols Road, Detroit 12, U. S. A.

White Saves 30% — Improves Gas Tanks

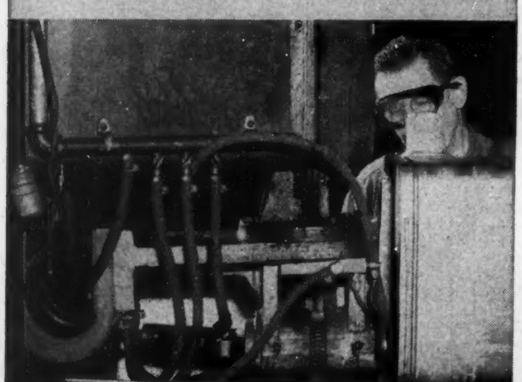
...by Resistance Welding



Welding 44½" pressure tight seam



Spot-welding baffles inside tank



Ends are assembled with 102" of pressure tight seams

When the White Motor Company switched to resistance welding in the fabrication of gasoline tanks for its motor trucks, White found that the tanks were not only stronger and more leak-proof, but also cost 30% less as they came to the assembly line.

Only 4 Progressive machines were required by White to take care of its production requirement of 100 complete tanks per shift. With the savings made, these machines—two spot welders and two seam welders—should pay for themselves in less than six months.

That's the kind of job resistance welding is doing all over. Sometimes the savings are a little less—sometimes even greater, depending on the nature of the job.

But—you cannot afford today not to investigate how much money you can save in production by switching to resistance welding. Progressive's Process Engineering Department will be glad to work with you in figuring the type of process, any minor changes in design, type of equipment needed, and potential savings.

In the meantime, are you receiving the "Welding Pictorial" published monthly by Progressive to acquaint industry with the latest methods and machines?

These 4 machines improved the quality of White gasoline tanks yet cut cost 30%.

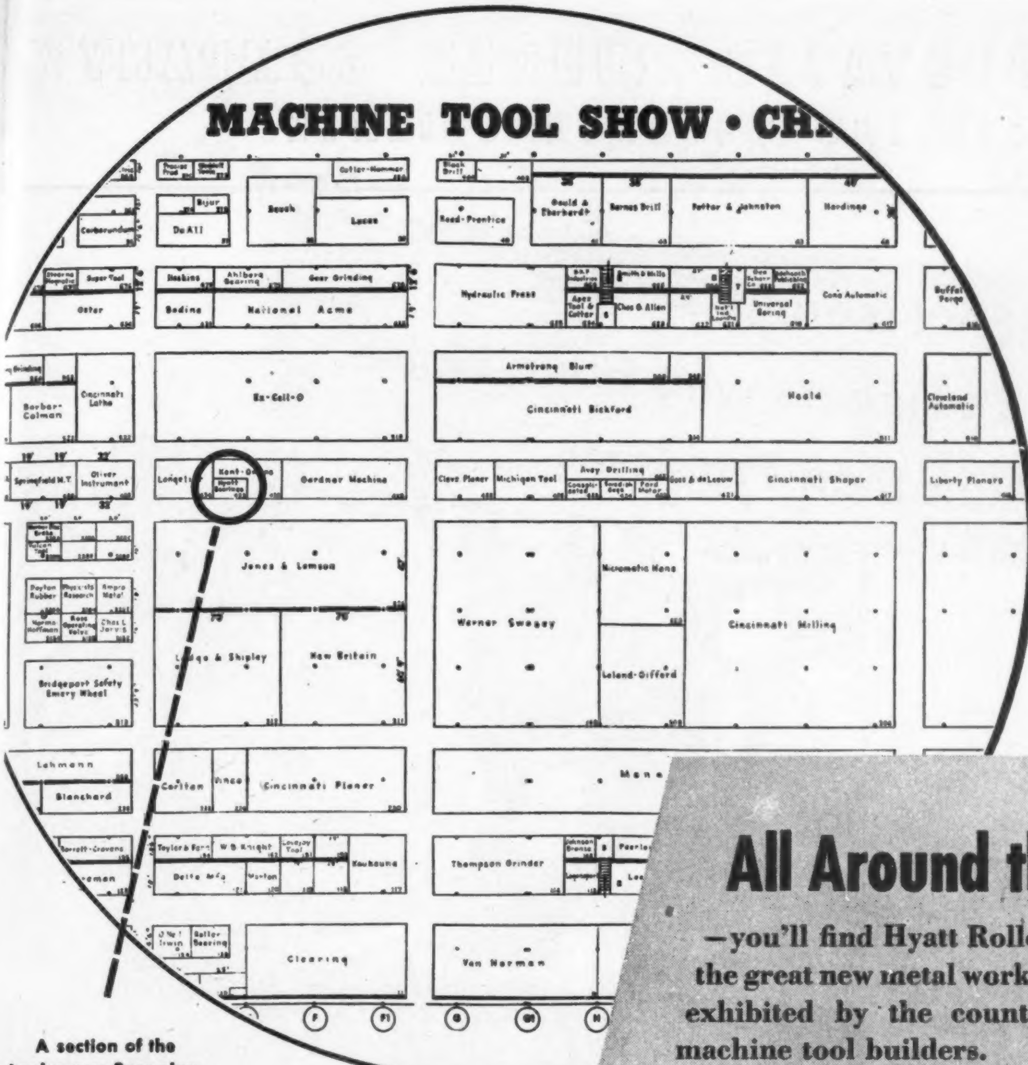
IT PAYS TO WELD

CABLE ADDRESS "PROGWELD"

MEMBER RESISTANCE WELDER MANUFACTURERS' ASSOCIATION RWMA

PROGRESSIVE Welder Co. 3050 E. OUTER DRIVE • DETROIT 12

RESISTANCE WELDING EQUIPMENT



A section of the twelve acre floor plan, showing Hyatt's location at
BOOTH 433

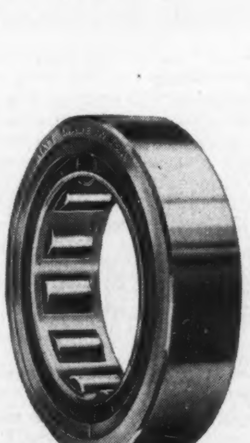
All Around the Show

—you'll find Hyatt Roller Bearings in the great new metal working machines exhibited by the country's leading machine tool builders.

—and you'll *see* Hyatt Roller Bearings on display at the Hyatt Booth, No. 433.

The Show, and Hyatt Roller Bearings, are *both* a great tribute to the progress of the Machine Tool Industry. For there is hardly a type of machine tool made that we don't use in the manufacture of our bearings.

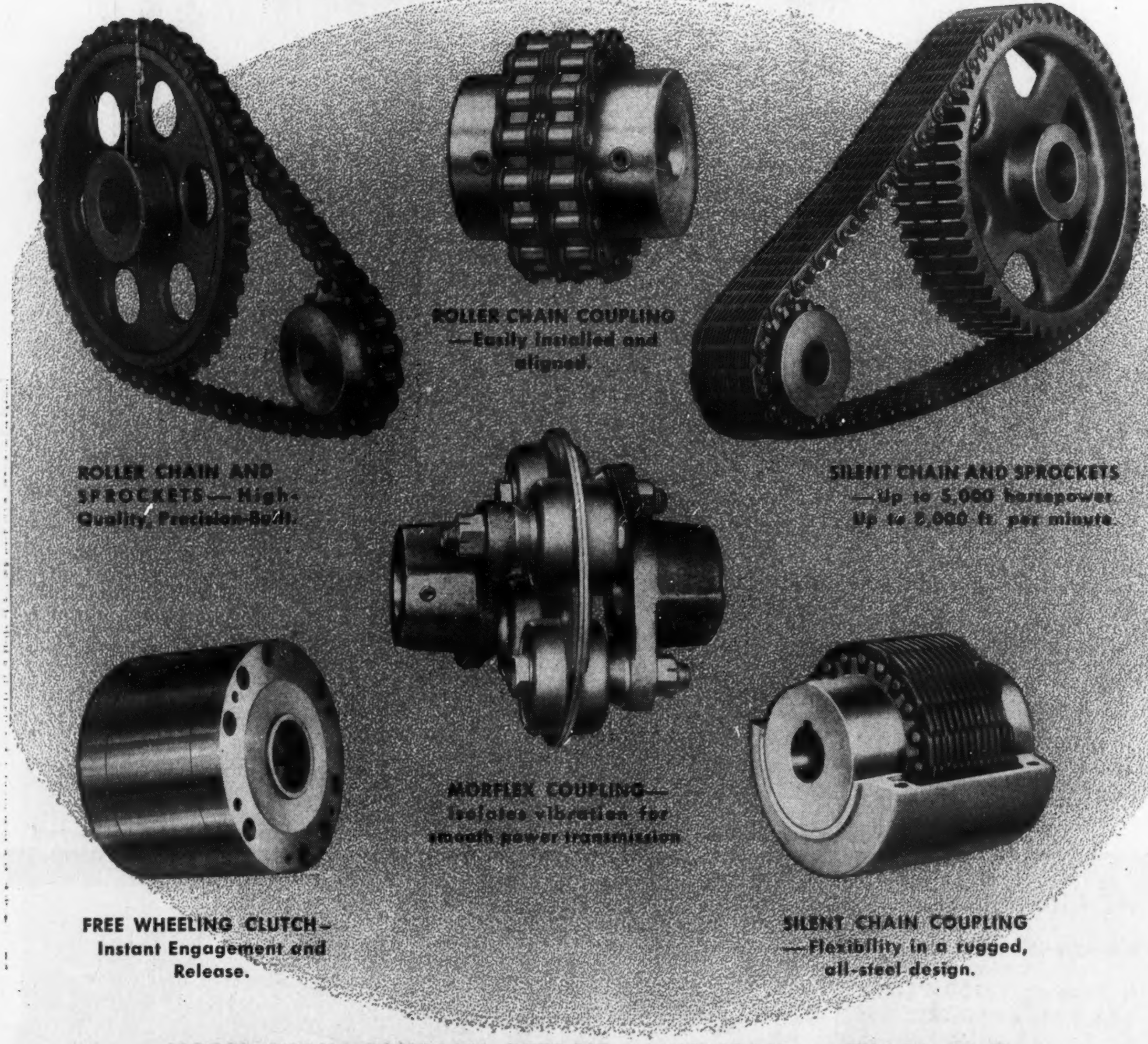
Better machine tools make better bearings. And better bearings make good machine tools better. That is why we are proud that today's better-than-ever Hyatt Roller Bearings are so well and widely represented at this greatest of all Machine Tool Shows. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.



HYATT ROLLER BEARINGS

The Answer to Mechanical Power Transmission Problems . . .

Throughout industry, machinery and equipment manufacturers use MORSE ROLLER and SILENT CHAIN DRIVES, FLEXIBLE COUPLINGS, FREE WHEELING, INDEXING and FRICTION CLUTCHES.



MORSE CHAIN COMPANY, DETROIT 8, MICHIGAN • ITHACA, N. Y.

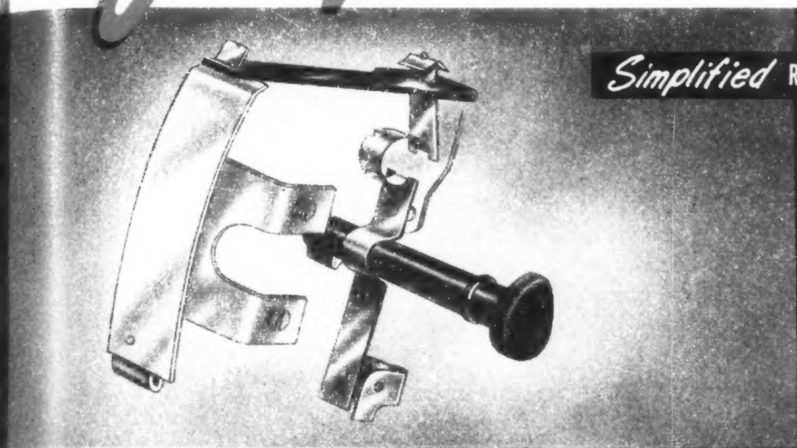
MORSE MECHANICAL POWER TRANSMISSION PRODUCTS

A PRODUCT OF B-W BORG-WARNER


Maintenance? ...
Where maintenance means money, SAVE with Federal NOARK Motor Starters!
For all the money-saving, time-saving details, get in touch with the local Federal Engineering Office now!
FEDERAL ELECTRIC PRODUCTS COMPANY, Manufacturers of a Complete Line of Electrical Products including Motor Controls • Safety Switches • Service Equipment • Circuit Breakers • Panelboards • Switchboards • Bus Duct
EXECUTIVE OFFICES: 50 Paris Street, Newark 5, N. J.
Plants: Hartford, Conn. Newark, N. J. St. Louis, Mo. L. I. City, N. Y.
Federal NOARK
Federal NOARK
MOTOR STARTERS
SIZE 5
SIZE 4
SIZE 3
SIZE 2
SIZE 1
SIZE 0

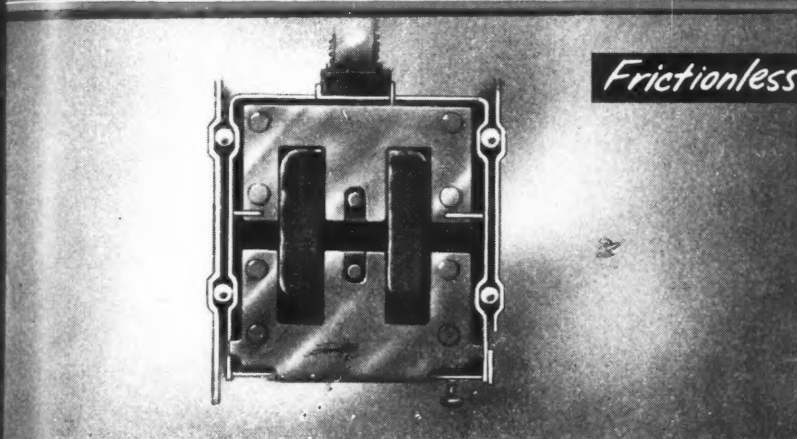
...forget it!

Where maintenance means money, SAVE with Federal NOARK Motor Starters!



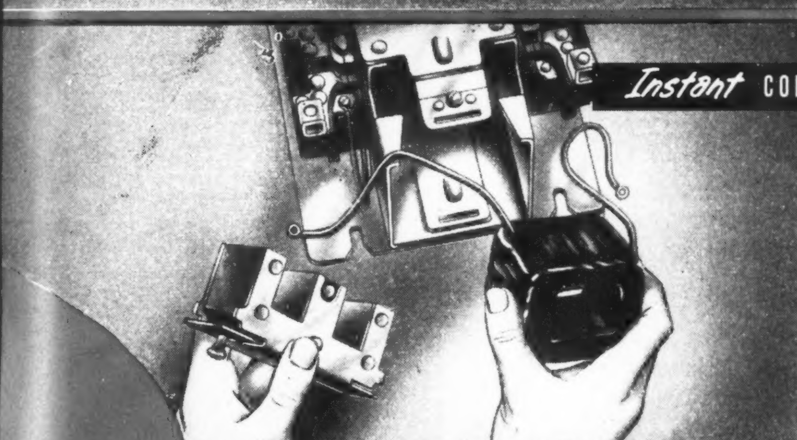
Simplified RESPONSIVE ELEMENT

"Here's an overload relay whose sound engineering is characteristic of every working part in a Federal NOARK Motor Starter. This quick make-quick break relay, activated by a bimetallic strip, can never fail — because there's nothing to get out of order. Resetting is positive. And a turn of a knob gives you a choice of *manual* or *automatic* reset instantaneously."



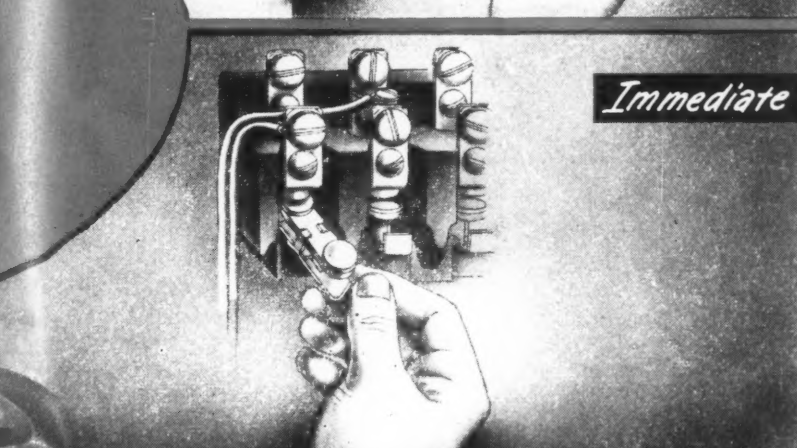
Frictionless SOLENOID ACTION

"Ball bearings—right where they count—eliminate friction . . . and trouble, too . . . in every Federal NOARK Motor Starter. One moving part means only one chance for mechanical trouble to develop . . . and, when that moving part rides on ball bearings, breakdowns are a thing of the past. You can see for yourself why maintenance problems are practically unheard of where these starters are installed."



Instant COIL REPLACEMENT

"Replacement of coils is a quick, simple operation on a Federal NOARK Motor Starter. 1—You press the coil retaining spring up and pull out. 2—Loosen a screw and lift the movable magnet out. 3—Disengage the coil leads from the overload relay terminals—and pull the coil out. A *fresh coil* goes in place in *seconds*. Your own eyes tell you that the simplicity of Federal design is an advantage that saves time—where time is important."



Immediate CONTACT RENEWAL

"Renewing the solid silver contacts in a Federal NOARK Motor Starter is as easy as signing your name. No need for tools of any kind! Simply press one end of the contact down, and it slides out of its groove without effort. Slide in a new contact, and the job is finished. And, once it's in, it stays in. It can't loosen or vibrate out!"

WHEN YOU SAVE PRODUCTION TIME BY USING FEWER TYPES AND SIZES...THAT'S

t.f.e.

True Fastener Economy!

It's the cost of using a fastener that counts

And an important part of the cost of using a fastener is the cost of maintaining inventories, requisitioning from stock, handling many different styles and sizes. Careful analysis of fastening requirements and standardization on fewer types and sizes will help to speed up production and lower costs.

R B & W *Machine and Carriage Bolts Offer You Unlimited Variety*

RB&W engineers are available to help you determine the minimum variety of types and sizes of bolts and nuts which will meet your needs. And RB&W offers the maximum range of product, a choice of many special metals, and the facilities of a versatile finishing department—from a *single* source of supply.

You Get T. F. E. *When You*

1. Reduce assembly time to a minimum by savings through use of accurate and uniform fasteners
2. Make your men happier by giving them fasteners that make their work easier
3. Reduce need for thorough plant inspection, due to confidence in supplier's quality control
4. Reduce the number and size of fasteners by proper design
5. Purchase maximum holding power per dollar of initial cost, by specifying correct type and size of fasteners
6. Simplify inventories by standardizing on fewer types and sizes of fasteners
7. Save purchasing time by buying larger quantities from one supplier's complete line
8. Contribute to sales value of final product by using fasteners with a reputation for dependability and finish

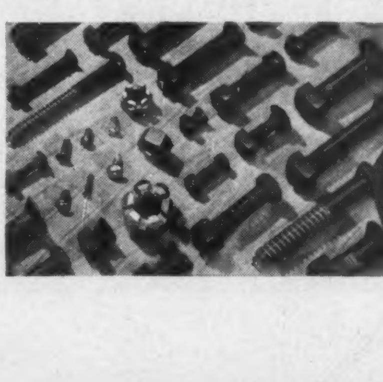
RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

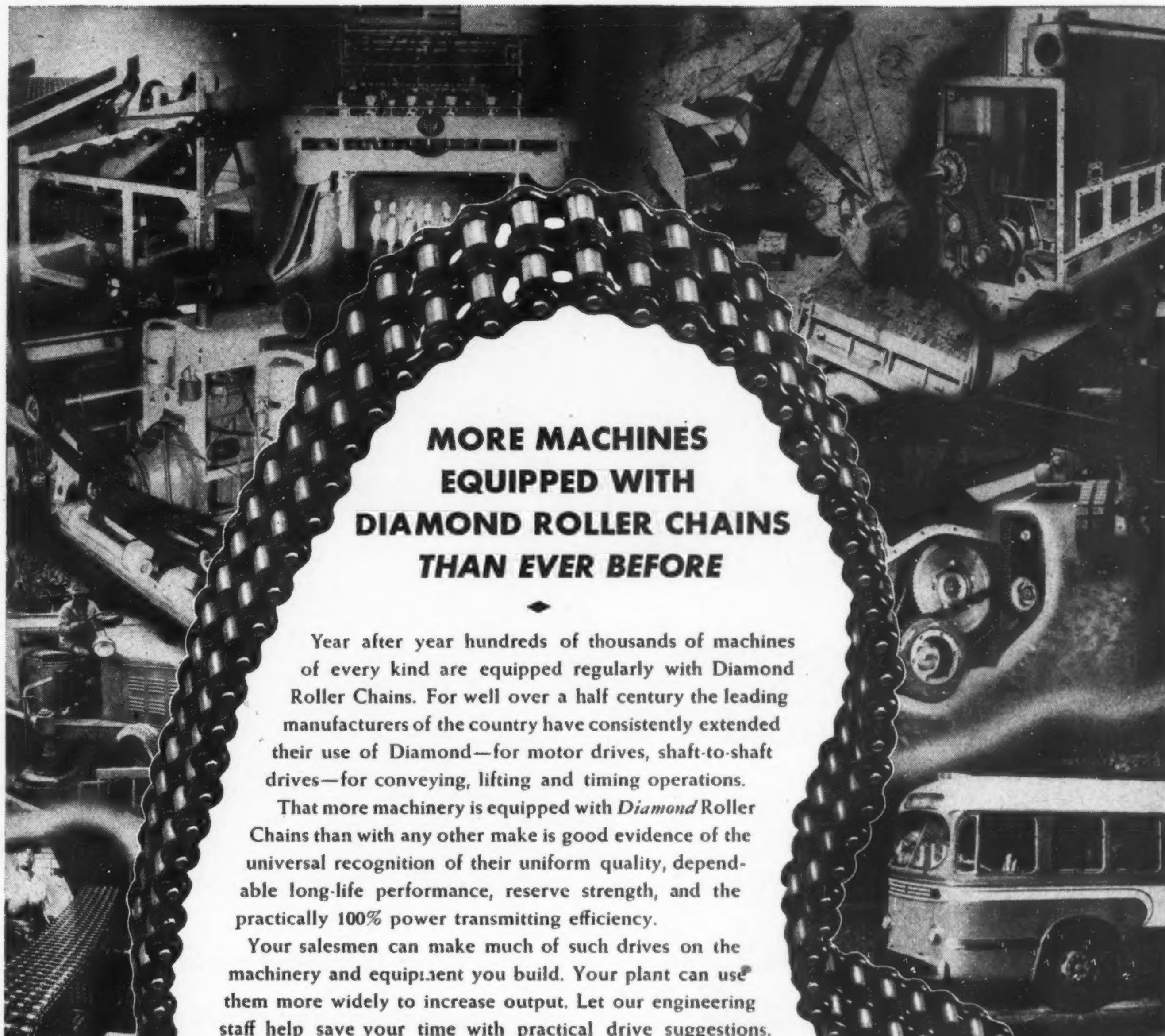
102 years making strong the things that make America strong

RB&W bolts, nuts, screws, rivets and allied fastening products are manufactured in a broad range of styles, sizes and finishes.

• • •

Plants at: Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at: Philadelphia, Detroit, Chicago, Chattanooga, Portland, Seattle. Distributors from coast to coast. By ordering through your distributor, you can get prompt service from his stocks for your normal needs. Also—the industry's most complete, easiest-to-use catalog.




MORE MACHINES EQUIPPED WITH DIAMOND ROLLER CHAINS *THAN EVER BEFORE*
Year after year hundreds of thousands of machines of every kind are equipped regularly with Diamond Roller Chains. For well over a half century the leading manufacturers of the country have consistently extended their use of Diamond—for motor drives, shaft-to-shaft drives—for conveying, lifting and timing operations.
That more machinery is equipped with *Diamond* Roller Chains than with any other make is good evidence of the universal recognition of their uniform quality, dependable long-life performance, reserve strength, and the practically 100% power transmitting efficiency.
Your salesmen can make much of such drives on the machinery and equipment you build. Your plant can use them more widely to increase output. Let our engineering staff help save your time with practical drive suggestions.
DIAMOND CHAIN COMPANY, Inc., Dept. 435, 402 Kentucky Ave., Indianapolis 7, Ind. Offices, distributors in all principal cities.
DIAMOND ROLLER CHAINS
Catalog No. 617 with 96 pages of useful data is yours for the asking.

THE STEEL IMPROVEMENT & FORGE CO.

DROP FORGINGS

970 EAST 64TH STREET

CLEVELAND, OHIO

ZONE 14

C. H. SMITH, JR., PRESIDENT

A S E R V I C E - - -

The I M P R O V E M E N T of
M E T A L S by F O R G I N G

What It Means to Users of Forgings

1. Sound Engineering Experience (over 34 years) in utilizing carbon, alloy, and stainless steels as well as high temperature alloys and other forgeable metals, and in discerning what is required beyond traditional forging techniques to meet a specific service requirement, and in developing suitable equipment for forging a wide range of intricate designs.

2. Design Suggestions resulting from hundreds of applications of closed impression die forgings, including actual designing of many parts as forgings, also advice and assistance to designers regarding the correct placement of parting lines and other design elements having an influence on quality, and on cost at the point of assembly.

3. Recommendations covering best methods of obtaining physical properties required to meet given service conditions, and how to utilize fully the qualities inherent in a specific grade of steel to protect your product against failure.

4. Projection of a Promise of quality and delivery only when such a promise can be substantiated by experience and know-how that results in the avoidance of costly experimentation.

5. Estimates of Cost Reducing Possibilities which may be obtained through, (1) utilization of greater strength in lighter sectional thicknesses available in forgings, (2) rapid assembly of complex parts by welding forgings, (3) reductions in time required to machine and finish, (4) reductions in rejects due to forgings being unusually free of hidden defects.

6. Technical Facts derived from the accumulated experience (over 34 years) of Steel Improvement Engineers and Metallurgists, which may be useful in determining to what specific extent applications of forgings may contribute to over-all product improvement.

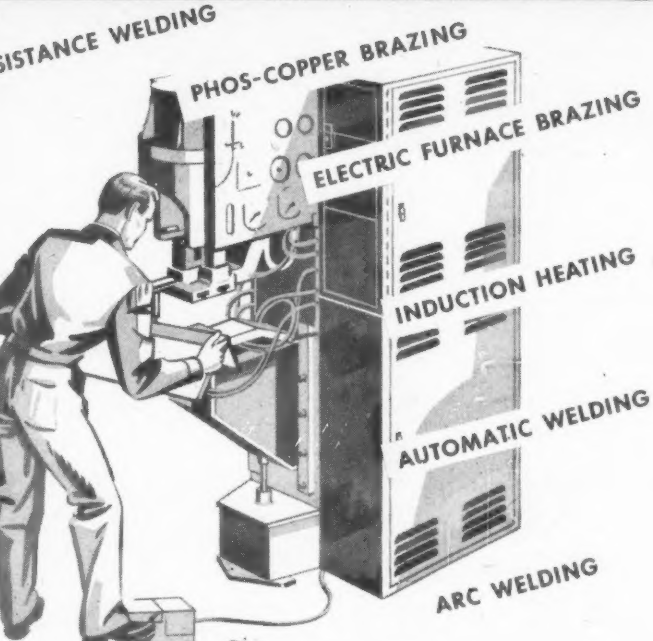
C H Smith Jr

C. H. Smith, Jr.
President

Use these ***IMPROVED***

METAL-JOINING METHODS

TO PRODUCE ***BETTER • FASTER • CHEAPER!***



Approximately 20 percent of all production costs in American factories can be attributed to metal-joining. So, here is an important operation to examine for possible application of improved production equipment and methods.

Westinghouse manufactures most types of metal-joining equipment—and has gained the experience of applying this equipment in a wide range of industries, as well as in its own manufacturing operations. Whatever your metal-joining problem, Westinghouse can provide the *right* equipment and methods to perform nearly any job.

On the next two pages are examples of seven *proved* production methods, already working in many plants. Any one of them may help you turn out your products *better . . . faster . . . cheaper!*

***FOR EXAMPLE . . .* If you assemble small parts in your plant:**

1. Must you increase production and cut costs in joining sheet metal?
2. Do you need a mass-production method of joining small but heavy metal pieces of uniform sizes?
3. Are castings slowing down your production . . . by slow deliveries, rejections, weight or bulkiness?
4. Do you need a quick and cheap method of joining copper or copper-alloys without the use of flux or acid?

For answers to questions like these . . . turn the page

WESTINGHOUSE

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Investigate these PROVED METAL-

TO CUT COSTS, SAVE TIME,

Resistance Welding, with synchronous precision timing, saved $100,000 a year . . . for a manufacturer of metal cabinets. It eliminated 600 tons of steel, 10,000 man-hours, 3,000 pounds of welding rod . . . permitted use of lighter stock without impairing strength or tolerance . . . reduced scrap losses. Synchro-trol, a new Westinghouse resistance welding electronic control, offers similar advantages. (Write for Resistance Welding Hint No. 1 and B-3830.)

$85.00 savings per unit by A-C Arc Welding . . . when this company switched from casting cylinder heads to welding them of ¾″ boiler plate. Results: *better, stronger* cylinder heads . . . and *200 pounds of weight eliminated.* (For more information, write for B-3548.)

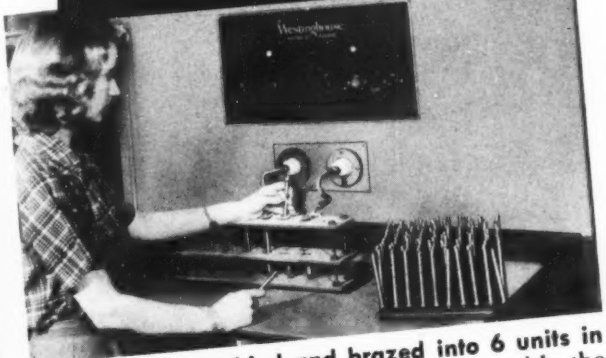
Electric Furnace Brazing cut factory costs 52% on this pump muffler by brazing separate baffles to the outer shell, instead of casting the unit as a single piece. (For equipment details, write for descriptive data DD-28-140, 28-450, 28-460.)

JOINING METHODS

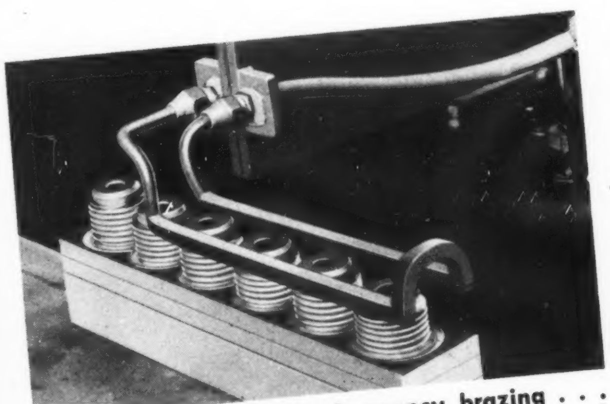
IMPROVE PRODUCTS

Here are seven examples of metal-joining that have helped make products better, faster, cheaper. Each is a potential cost-cutter for you. For more detailed information on any of these metal-joining methods—call your Westinghouse office.

FASTER

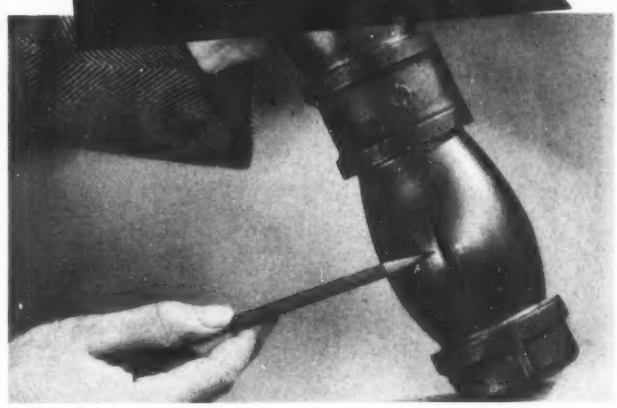


18 pieces assembled and brazed into 6 units in 7 seconds by induction heating . . . with the aid of a simple jig. The normal method of flame brazing this steel tube assembly required two minutes to complete *one assembly of three pieces.*

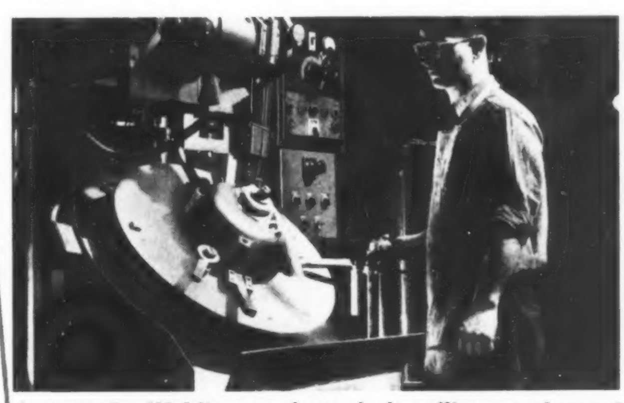


"Production line" radio-frequency brazing . . . these copper bellows are automatically brazed as a conveyer carries them through the work coil. Apparatus: radio-frequency generator, work coil and conveyer. (Write for B-3620.)

BETTER



Phos-Copper joints improved pressure resistance of joints as shown by this pressure test photo. The joints between the bronze caps and copper tube were still tight and sound when the tube burst at 2,200 psi. (Write for B-3201.)



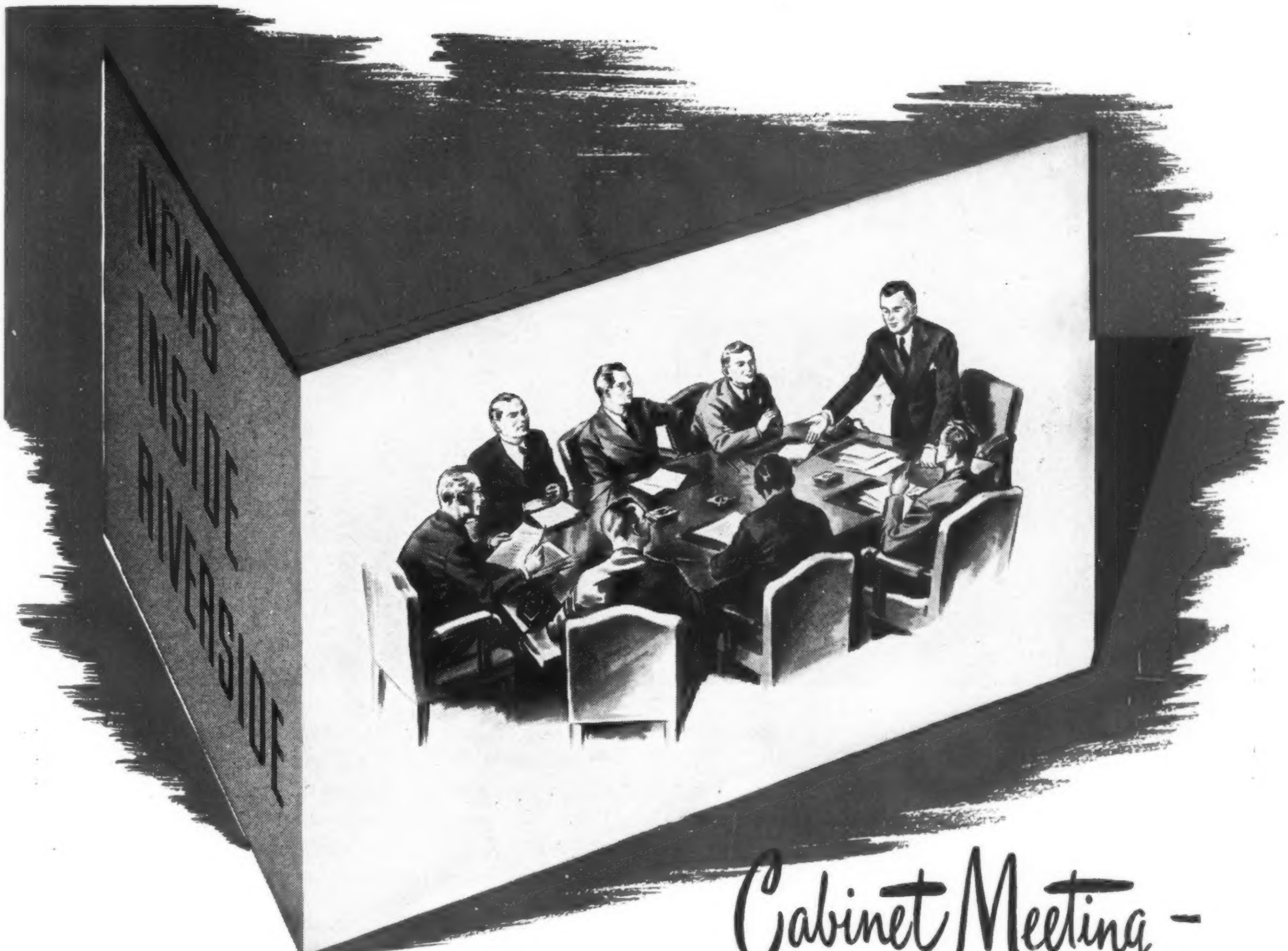
Automatic Welding and work handling equipment . . . in motor manufacture reduced frame size 35% . . . increased power capability 116% per pound . . . tripled production. For further information, call your nearest Westinghouse office.

FOR MORE PRODUCTIVE POWER...LOOK TO

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

HERE'S THE COMPLETE LINE OF WESTINGHOUSE METAL-JOINING EQUIPMENT



Cabinet Meeting -

EVERY WORKDAY RIVERSIDE'S TOP EXECUTIVES MEET TO OPEN, CONFER AND ACT UPON YOUR MAIL.

For the past 25 years Riverside has *daily* conducted a singular and most effective industry conference. Around a table sit the top operating men of every department concerned with the handling of an order, from acceptance to shipment.

All questions and problems in *each* letter, inquiry or order in that day's mail receives the full *consideration* of Riverside's Executive Officer, Chief Metallurgist, Works Manager, General Sales Manager, Mill Superintendent, Advertising Manager and Order Department Manager.

By airing freely the *details* of each problem, a complete agreement is quickly obtained and immediate action taken. Result: faster handling of all correspondence, prompt entry of orders into production schedule, and, best of all, days are lopped off lead time. Customers say (emphatically) that they like this friendly, personal attention and cooperation. It prevents misunderstandings, saves time, money, tempers.

Riverside alloys . . . *Phosphor Bronze, Nickel Silver* and *Beryllium Copper* are produced to specification. Do what many of our customers do daily, consult us about your individual requirement. We'll be glad to help. Call or write us today.

BIG ENOUGH TO BE HELPFUL • SMALL ENOUGH TO BE FRIENDLY

THE RIVERSIDE METAL COMPANY

RIVERSIDE, NEW JERSEY

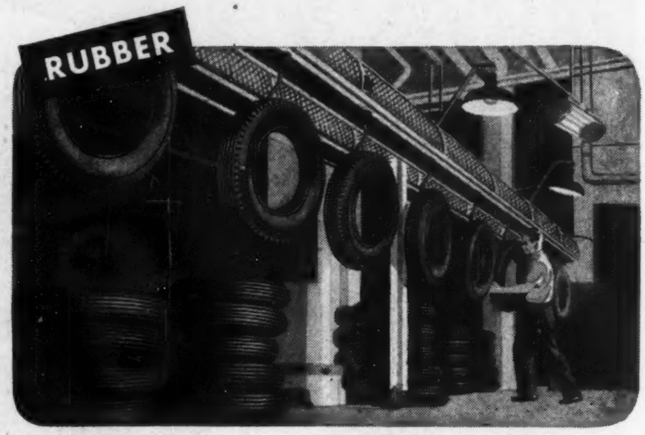
NEW YORK, CHICAGO, HARTFORD, CLEVELAND

RIVERSIDE

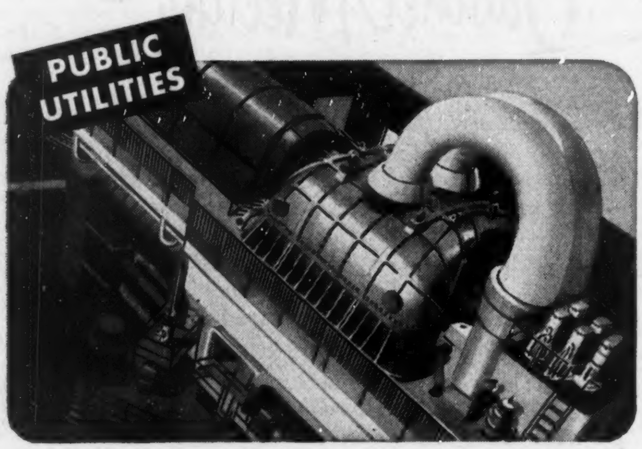
PHOSPHOR BRONZE
NICKEL SILVER
BERYLLIUM COPPER

Watch industry Fluid-Drive* ahead!

1 Constant speed A.C. motors are transformed like magic into adjustable speed units by the addition of Gýrol Fluid Drive. This modern method of Fluid Driving helps paper makers simplify equipment and cut maintenance costs. In this industry, Gýrol Fluid Drive transmits power to slitters, coaters, draft fans, rewinders, and conveyors.



2 Now conveyors can travel thousands of miles without a single broken shear pin! *Sounds fantastic*—but it's absolutely true for conveyors equipped with Gýrol Fluid Drive. The rubber industry protects equipment with Gýrol Fluid Drive. Conveyors start smoothly—under heavy load—with minimum power. Shear pin breakage is ended.



3 Thirteen years ago we made the first industrial installation of Gýrol Fluid Drive—on a Mechanical Draft Fan. Public Utilities have since discovered equally important uses on boiler feed pumps. In both applications, Fluid Drive provides stepless adjustable speed control, results in horsepower savings, simplicity of control, long equipment life, and increased overall power plant efficiency.

AND YOU?

Frankly, we cannot say where Gýrol Fluid Drive will next be used. However, if you have a power transmission problem, remember:

1 Standard constant speed A.C. motor, plus Gýrol Fluid Drive, equals stepless adjustable speed—in a compact, complete unit.

2 Thousands of Gýrol Fluid Drive applications prove its ability to give smooth load pick-up and eliminate strains of overloading.

Contact the nearest American Blower Branch Office. Our long experience is available to you!

For better performance get—

GÝROL *Fluid Drive*

** Gýrol Fluid Drive is a product engineered and developed for American industry by American Blower. It is designed for applications where smooth transmission of power or stepless adjustable speed control is desired. Looking beyond the long list of applications already developed, we will work with you to find new ways to "Fluid-Drive Ahead!"*

AMERICAN BLOWER

DETROIT 32, MICHIGAN

In Canada: CANADIAN SIROCCO CO., LTD., Windsor, Ont.

Division of American Radiator & Standard Sanitary Corporation


MRC
The M-R-C
"SYNTHE-SEAL" BEARING
Incorporated in this bearing are the refinements gained by over a half century of experience in the manufacture of ball bearings
A STANDARD-DIMENSION BALL BEARING WITH A REMOVABLE SYNTHETIC RUBBER SEAL IMPERVIOUS TO OILS AND GREASES
MARLIN-ROCKWELL CORPORATION, JAMESTOWN, N.Y.
SEE THIS BEARING AT BOOTH 156
MACHINE TOOL SHOW at the Dodge-Chicago Plant

More Gripping Area

. . . WHEN AND WHERE IT COUNTS!

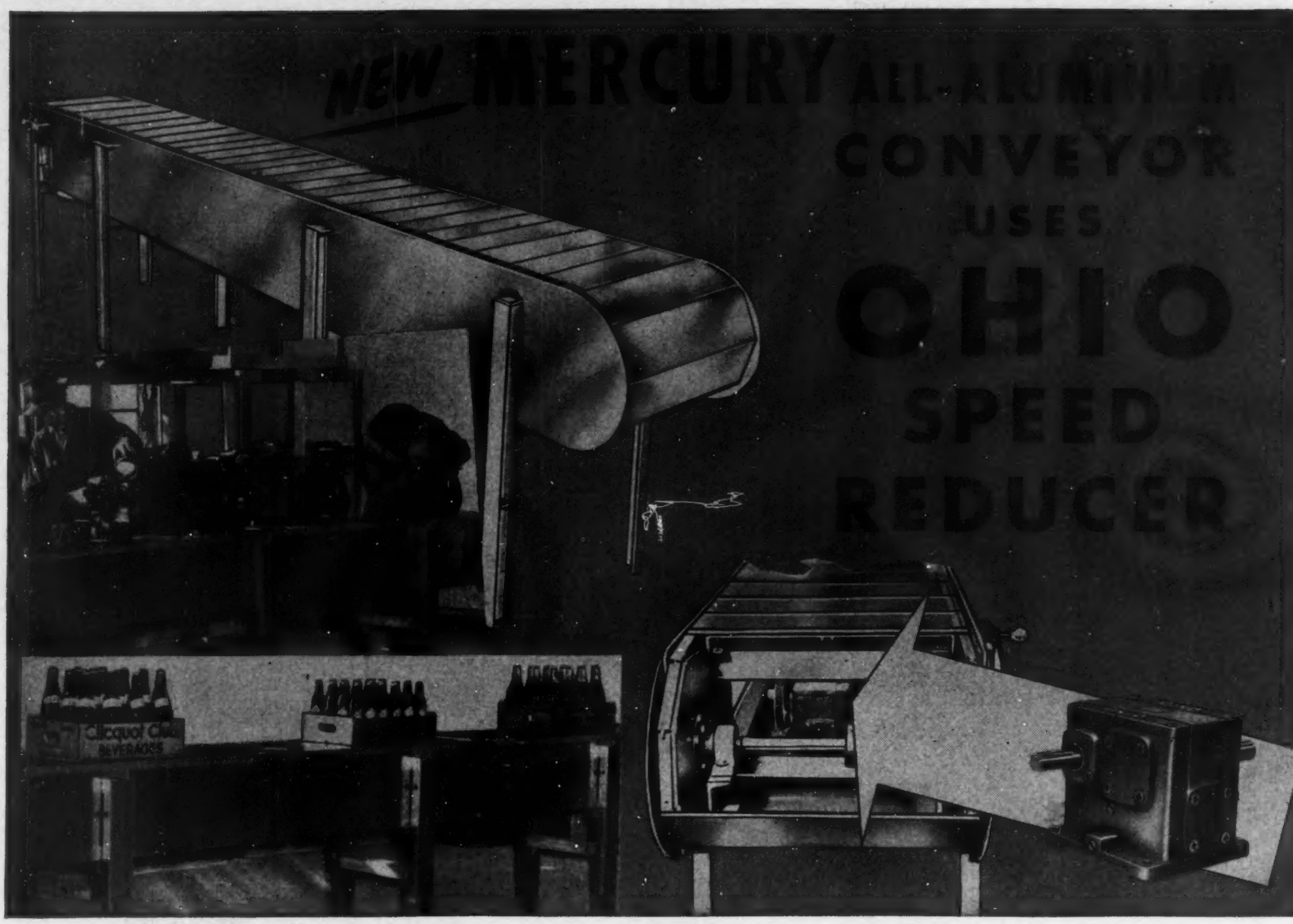
● Here's photographic evidence that EverLOCK washers really take hold with a grip that defies every loosening action. Note how EverLOCK wide chisel edges have dug into the contiguous faces of both work and nut to provide several times more area of resistance than other washers.

Guard your assemblies with EverLOCK . . . The Washer That Has The Edge. Fast, easy application saves assembly time—automatically safeguards against stretching of bolts or distortion of threaded parts. Four standard types meet most lock washer needs.

Ever LOCK WASHERS

THE WASHER THAT HAS THE EDGE

THOMPSON-BREMER & CO. 1636 W. HUBBARD STREET, CHICAGO 22, ILLINOIS



The new Mercury, All-aluminum belt conveyor recently announced by the Patron Transmission Co. of New York, marks a long step ahead in providing the advantages desired in a general purpose conveyor. Constructed wholly of aluminum it combines structural strength with lightness that insures ease in handling. The aluminum also makes the conveyor rust and corrosion proof and resistant to most acids, chemicals and fumes. This factor is of exceptional advantage where food is handled or where acid or fume conditions are present.

Prefabrication in 5 ft. sections allows unusual flexibility as the sections may be assembled into any required length in only a few minutes time. Load capacity is 250 lbs. per sq. ft. and speed may be set up to 100 ft. per minute.

Long familiarity with the sturdiness and splendid performance records of Ohio Gear Speed Reducers led the Patron Company to adopt the D1 as the most practical drive for their new product and the conveyors already in use in many nationally known plants substantiate that choice.

If a dependable speed reducer is part of the machines you build, it will pay you to check the advantages of Ohio Gear Speed Reducers. Get in touch with our nearest distributor or with us today.

THE OHIO GEAR COMPANY
1338 EAST 179th STREET • CLEVELAND 10, OHIO

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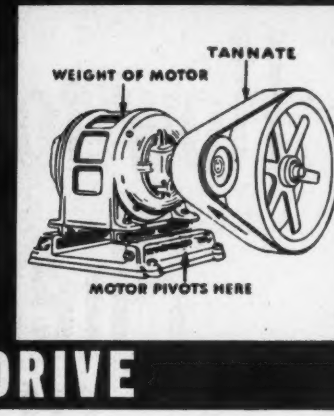
OHIO GEARS

RHOADS

Tannate-Rockwood



SHORT CENTER DRIVE

ASSURES YOU MORE PRODUCTION

1. **PROVIDES CONSTANT, UNIFORM SPEED** — higher hourly production, more uniform work, fewer shutdowns, less spoilage.
2. **CORRECT BELT TENSION** — automatically maintained, regardless of load fluctuation.
3. **SIMPLE, COMPACT, EASY TO INSTALL** — and they require a minimum of attention and maintenance.
4. **HIGH OVERLOAD CAPACITY** — pivoted motor base provides greater load capacity. Belt is automatically tightened when the load increases, and as the load decreases the tension on the belt and bearings is reduced.

TANNATE Belt operates smoothly at full capacity . . . carries full load when damp . . . withstands high temperatures, water, machine oils and many dilute chemicals. Pivoted motor base can be used with small or large motors . . . drives equally well horizontally, vertically, or suspended from the ceiling. For details about this dependable, reliable drive, write

PRODUCERS OF FINE LEATHER FOR 245 YEARS

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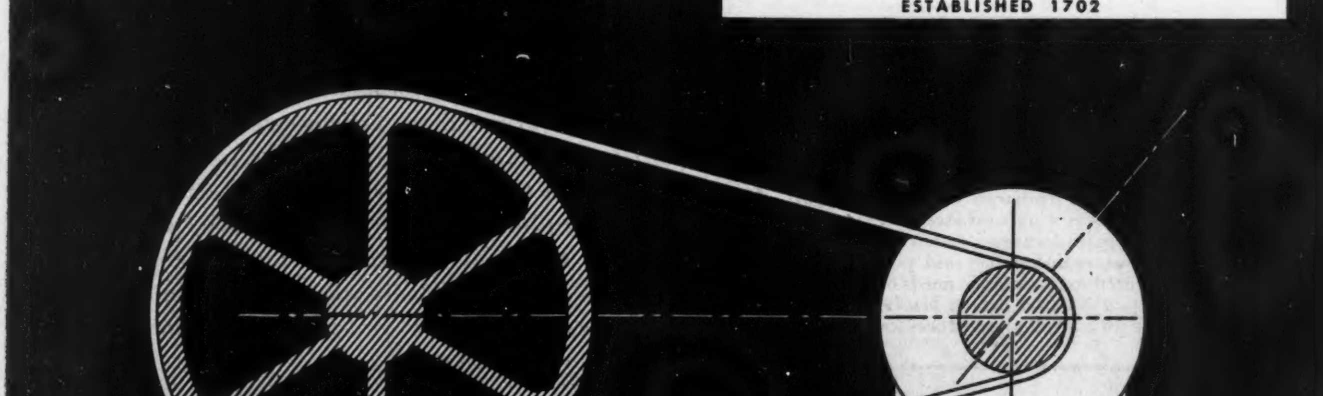


5-color magazine press prints to perfection with Farval on the job

THE press on which the color section of one of America's big national magazines is printed was doing a very indifferent job. Satisfactory 5-color printing, on heavy enameled stock, at high speed, required much higher bearing pressures—and the superintendent didn't dare screw the adjustments down any further. It just wasn't possible, with hand oiling, to supply enough lubricant to the bearings to keep them operating under greater pressures.

Then a Farval centralized lubricating system was put on the press, arranged to oil the bearings automatically, at 30-second continuous intervals. This step solved the problem. It is now possible, without danger to the bearings, to adjust the pressure to the exact point where perfect plate impressions and beautiful color reproduction are obtained.

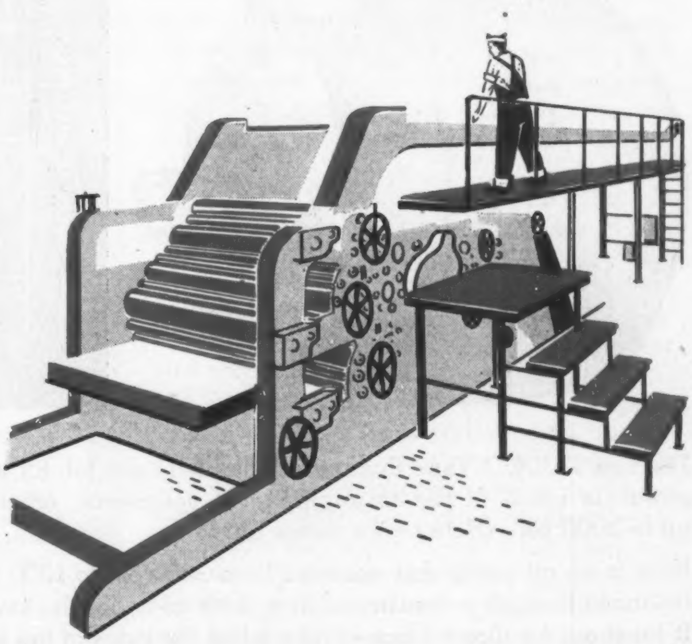
Since Farval was installed there have been no bearing troubles, no shutdown periods for lubrication and no complaints of poor printing. Farval centralized lubrication made the difference.

Farval delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, while a machine is in operation. Farval is the Dualine System with the Positive Piston Displacement Valve. This valve has but two moving parts and is fully adjustable, with a Tell-tale indicator at each bearing to show the job is done.

For a full description of Farval, write for Bulletin 25. The Farval Corporation, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

FARVAL—*Studies in Centralized Lubrication*
No. 94



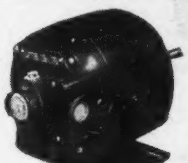
FARVAL

CENTRALIZED SYSTEMS OF LUBRICATION

Once Again General Electric Offers

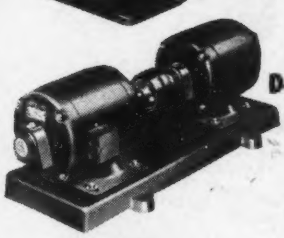
Short Deliveries

On D-C FHP Motors and Generators



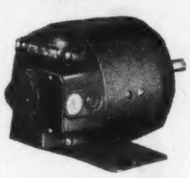
GENERAL-PURPOSE D-C MOTORS

Designed for general-purpose applications. Often used with a-c and d-c conversion equipment. Gives you quiet operation. Comes in wide range of horsepower ratings and speeds.



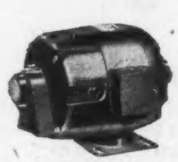
D-C GENERATORS AND MOTOR-GENERATOR SETS

Recommended as d-c power unit for industrial devices or as exciters for large equipment. Available in output ratings of 125, 250, and 500 watts continuous duty; 125 and 250 d-c volts.



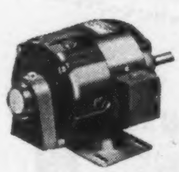
LOW-VOLTAGE SPECIAL D-C MOTORS

Operate from power sources commonly used on busses, trucks, railroad equipment, battery-operated industrial trucks, etc. Sturdy adaptable motors, built usually from general-purpose motor parts.



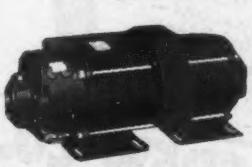
DYNAMOTORS

Give you reliable means of converting d-c power to other voltages, or to a-c. Recommended for neon signs, locomotive headlights, communication equipment, etc. A light but sturdy unit.



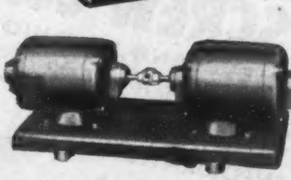
A-C GENERATORS

Offer you effective source of a-c current for places where it otherwise would be unobtainable. Available in standard ratings. Strong, well constructed power units.



MOTOR AMPLIDYNE-GENERATOR SETS AND AMPLIDYNE GENERATORS

Give unusually quick response over a wide range of operating loads. Thus, the amplidyne generators are suitable for many applications. Available in single units or assembled with motor drive.



HIGH-FREQUENCY MOTOR ALTERNATORS

Highly recommended for testing equipment and source of power supply for high-frequency machines. Small and lightweight units, but sturdy and hard-working.

It has been a long time since we have talked about short deliveries on fractional-horsepower motors. But our engineering and manufacturing facilities are now available to give you just that on d-c fhp motors, generators, and motor-generator sets. Whether you require a few motors or many, we are ready to help you.

Available for quick short deliveries are general-purpose d-c motors, d-c generators and motor-generator sets, low-voltage special d-c motors, dynamotors, a-c generators, motor amplidyne-generator sets and amplidyne generators, and high frequency motor alternators.

These equipments have a variety of applications. Our staff of experienced fractional-horsepower motor engineers can help you with design and application problems. These men accumulated a vast store of new "know how" from thousands of war jobs. Combine this with previous accumulation of design knowledge and application experience, and you have 46 years of experience at your service.

Whether it is a new or old application, we can help you. Save you time and money, too! For more information on the kinds of equipments we can offer you for quick delivery, write for GEA-4871, or call your nearest G-E office.

Mail This Coupon For Bulletin Describing Available D-c, Fhp Equipments

General Electric Company
Apparatus Dept., Section C700-84
Schenectady 5, N. Y.

Please send me bulletin, GEA-4871, which describes G-E d-c fractional-horsepower motors and generators available for short delivery.

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Company...

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STANDARDS and SPECIALS
by the Millions
Simply Specify -
"SHINYHEADS"
NC or NF Thread
"HI-CARBS"
NC or NF Thread
"SHINYLANDS"
Standard Thread
"SHINYHEADS"
America's Best Looking Cap Screw
Made of high carbon steel—AISI C-1038—to standards for full finished hexagon head cap screws. Heads completely machined top and bottom. Hexagon faces clean cut, smooth and true, mirror finish. Carried in stock.
"HI-CARBS"
Heat Treated Black Satin Finish
Made of high carbon steel—AISI C-1038. Furnished with black satin finish due to heat treatment. Hexagon heads die-made, not machined. Point machine turned; flat and chamfered. Tensile strength 130,000-160,000 p.s.i. Carried in stock.
FLAT HEAD CAP SCREWS
Heads completely machined top and bottom. Milled slots—less burrs. Flat and chamfered machine point. Carried in stock.
FILLISTER CAP SCREWS
Heads completely machined top and bottom. Milled slots—less burrs. Flat and chamfered machine point. Carried in stock.
"SHINYLAND" STUDS
All studs made steam-tight on tap end unless otherwise specified, with flat and chamfered point. Nut end, oval point. Carried in stock.
SET SCREWS
Square head and headless—cup and oval point—case hardened. Carried in stock.
CONNECTING ROD BOLTS
Made of alloy steel—heat treated—threads rolled or cut—finished to extremely close thread and body tolerances—body ground where specified.
"SHINYTHREADS"
AIRCRAFT ENGINE STUDS
Made of highest aircraft quality alloy steel, finished to extremely close thread and body tolerance, with precision rolled threads—both straight and step types.
VALVE TAPPET ADJUSTING SCREWS
Hexagon head style—to blueprint specifications—hexagon head hard; polished if specified—threads soft to close tolerance.
SPRING BOLTS
Case hardened to proper depth and ground to close tolerances. Thread end annealed. Supplied in various head shapes, with oil holes and grooves of different kinds, and flats accurately milled.
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Pioneers and Recognized Specialists, Cold Upset Screw Products since 1907
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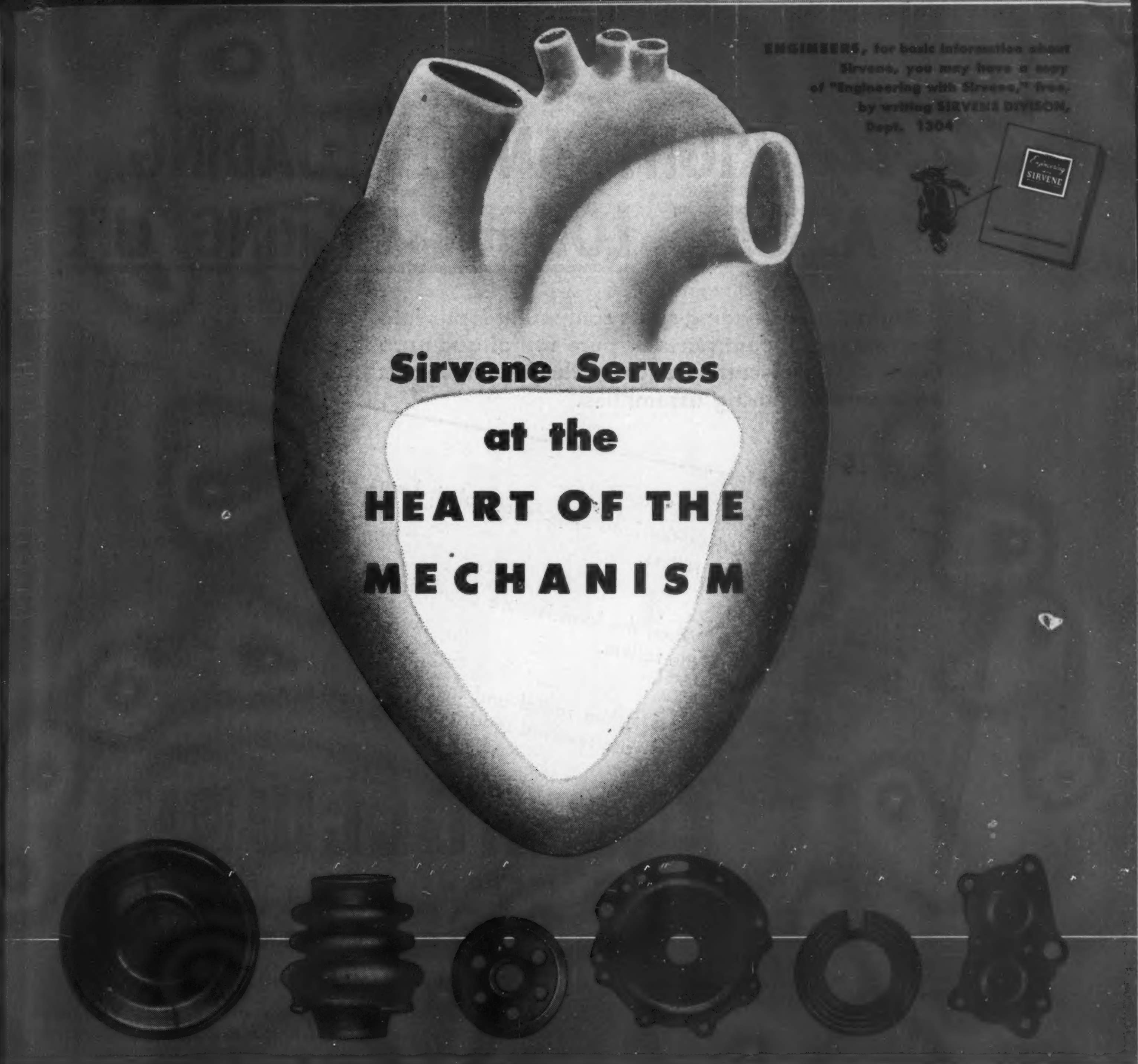
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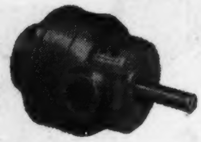
7 KEYS

TO INDUSTRIAL EFFICIENCY

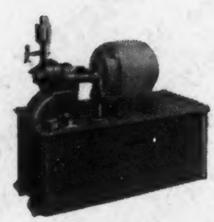
GEROTOR

HYDRAULIC PUMPS



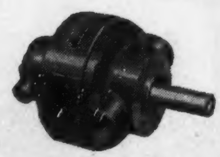
Positive displacement rotary type for hydraulic oils. Pressures up to 1000 p.s.i., continuous duty; in some sizes, up to 1200 p.s.i., continuous, and 1500 p.s.i., intermittent. Deliveries range from .4 g.p.m. at 1800 r.p.m. to 40 g.p.m. at 1200 r.p.m. Plain, base or flange mounting. Double-unit models available for two separate circuits. Write for Catalog Sections G-101, G-103, G-104, G-106.

HYDRAULIC PUMP UNITS



Deliver a steady oil flow at continuous pressures up to 1000 p.s.i. (1200 in some pump sizes) for one or two circuits. Single pump units have tank capacities from 4½ to 100 gallons, double units from 10 to 100. Each complete with tank, relief valve, gauges, filter, coupling, piping. Standard for N.E.M.A. frame motors, but special motors can be used. Write for Catalog Section G-105.

HYDRAULIC MOTORS

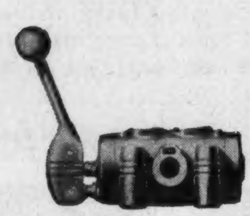


Sizes up to 8.7 h.p. Efficiently convert hydraulic power into rotary power. Have many industrial applications due to unique operating characteristics: Can be stalled under load without damage, operated safely in explosive and corrosive atmospheres, installed in small, confined spaces. Low rotational inertia. Two models with plain, base or flange mounting, for direct coupling, belt, chain or gear drive. Write for Catalog Section G-108.

HYDRAULIC AND AIR CYLINDERS

Keeper ring construction eliminates tie rods, permits compact design and rotation of covers to convenient pipe location. AIR: Double-acting, non-rotating, in 7 standard mountings, 9 bore diameters, strokes up to 96". HYDRAULIC: Double-acting, in 7 standard mountings, 10 bore diameters, strokes up to 96". Standard piston rod size and 2:1 differential over-size rod. Write for Catalog Sections 52 (air), 102 (hydraulic).

HYDRAULIC AND AIR VALVES



For easy, accurate, positive control of double-acting cylinders. AIR: Pressures up to 150 p.s.i. Hand, foot, solenoid, cam and pilot operation. ¼", ⅜", ½", ¾" and 1" sizes. HYDRAULIC: 4-way valves for oil up to 1500 p.s.i. (also 3000 p.s.i.) Standard, spring-return, spring-centered, and ball-detent action. 5 piston sizes for any hydraulic circuit. Write for Catalog Section 300 (air), 200 (hydraulic).

GEROTOR

AIR & HYDRAULIC DEVICES

GEROTOR MAY CORP., BALTIMORE 3, MD.

Any way you figure it

NORMA-HOFFMANN PRECISION BEARINGS

are the Right Answer

NORMA-HOFFMANN BALL BEARINGS

Rugged—thoroughly dependable for carrying thrust and radial loads.

NORMA-HOFFMANN ROLLER BEARINGS

Short, cylindrical roller design . . . heavy-duty bronze retainer . . . lowest possible co-efficient of friction under heavy load.

Norma-Hoffmann heavy-duty Bearings improve the design and performance of products wherever they are used. They are dependable, give friction-free smoothness and quietness of operation. Available in a wide range of sizes for every load, speed and duty. Write for catalog and engineering assistance.

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***Precision* BEARINGS**
BALL • ROLLER • THRUST

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For 78 years Keuffel & Esser Co. drafting equipment and materials have been partners, in this sense, in shaping America, in making possible its swift-moving highway traffic, its speed in conducting business, its victorious might in war ...So universally is K & E equipment used, it is self-evident that every engineering project of any magnitude has materialized with the help of K & E. Could you wish any surer guidance than this in the selection of your own "drafting partners"?

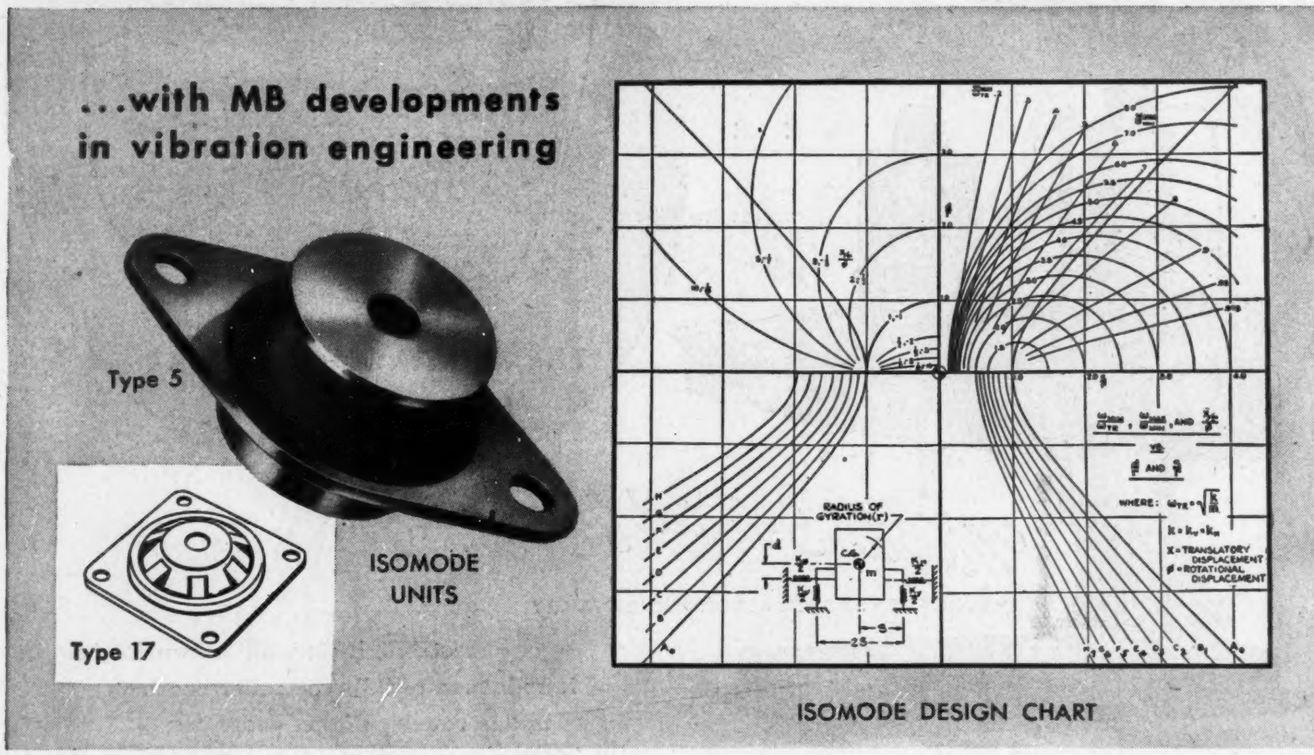
partners in creating

You will find special advantages, for example, in PHOENIX* Tracing Cloth, which K & E has made almost "ghost-proof." Here is a cloth from which you can erase either pencil or ink lines without risking untidy "ghosts" on the prints, a cloth practically immune to stains from perspiration and water. You can even soak it in water for ten minutes at a time without harm! For further details about PHOENIX* Tracing Cloth, write on your letterhead to Keuffel & Esser Co., Hoboken, N. J.

*REG. U. S. PAT. OFF.

GREAT NEWS!

VIBRATION CONTROL now SIMPLIFIED



ISOMODE DESIGN CHART

HERE'S A REMARKABLE, new method of locating support points for flexible mountings. It reduces your difficult design problem to an almost routine job. And what's more, it assures you *optimum* isolation every time, from standard units, with mathematical certainty! Here are partial details:

THE MB ISOMODE* DESIGN CHART SAVES WORK, SAVES TIME

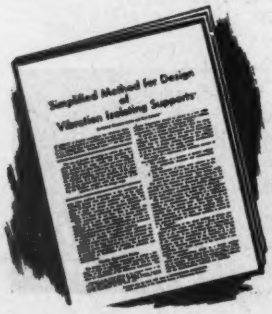
Set down graphically are the relationships you formerly found by trial and error. Each quadrant covers a different phase of the entire vibration problem. You outline your product right onto the chart. Then read your solutions directly from intersections of various curves and mount-locations of product.

THE MB ISOMODE* UNIT— CLINCHES THE RESULTS

You can install these units at any convenient angle—because MB engineered them with an equal spring rate in all directions. That's also why they isolate with extra high efficiency. For the same radial and axial softness absorbs not only vertical, but *horizontal* and *rocking* motions as well! They have high deflection capacity, yet are thoroughly stable. Safe, self-snubbing, compact sizes are available for loads of ½ pound to 2500 pounds.

Why not investigate this simplified MB method? Give your product the benefit of vibration control accomplished in the *design stage*—and make no compromise on efficiency. You'll get a product that works more smoothly, lasts longer—and sells better!

*Trade Mark Reg. U. S. Pat. Off.



SEND FOR FREE REPRINT

This technical paper gives the information you need for better vibration control design. It describes the chart—shows you how to use it. No obligation, of course. Write Dept. B3.

THE MB MANUFACTURING COMPANY, INC.
1060 State Street
New Haven 11, Conn.

VIBRATION ISOLATOR UNITS • VIBRATION TEST EQUIPMENT

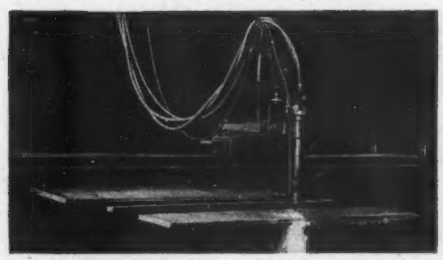
VIBRATION DIVISION

"Tailored steel" becomes a regular steel warehouse commodity when an OXWELD shape-cutting machine is used.

LINDE process service cuts production corners

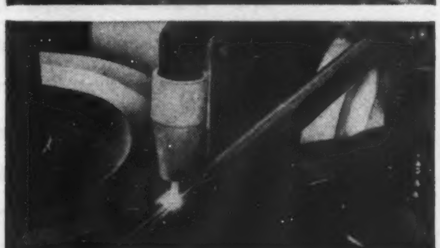
You may be taking advantage of all of the more apparent economies of LINDE methods. Yet, through the broad and comprehensive experience of the LINDE service organization, important additional savings may be made.

LINDE Process Service is available to all LINDE customers through any LINDE office.

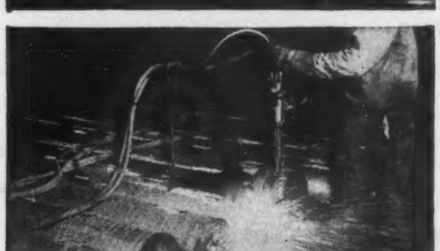


Stainless steel plate, difficult to oxygen-cut by usual methods, can be quickly cut to size and shape by powder-cutting.

Scrubbing steel with a brush of flame removes scale, rust, and surface moisture prior to painting. This is flame-priming, a LINDE development.



HELIARC welding makes strong, clean welds in stainless steel tubing because the weld zone is protected from oxidation by a protecting envelope of argon or helium gas.



The design of a simple jig for centering cold rounds—or the design of a completely mechanized flame-conditioning installation — are examples of LINDE Process Service.

Linde

The words "Linde", "Oxweld" and "Heliarc" are registered trade-marks of Units of Union Carbide and Carbon Corporation.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 East 42nd St., New York, 17, N.Y. UCC Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

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HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

58. Hose Fittings & Tools

Punch-Lok Co.—8-page illustrated catalog No. 235 deals with preformed clamps, open end clamps, Punch-Lok method of application and tools and accessories. Instructions for operating various kinds of Loking tools are given.

59. Screw Machine Parts

Wedler Bros., Inc.—4-page illustrated folder "Makers of Special Machined-From-The-Bar Products" presents details of company's facilities in making precision screw machine parts to any given specifications. Wide variety of shapes and sizes is depicted.

60. Vibration Dampeners

MB Mfg. Co.—4-page illustrated folder No. 405 presents information concerning Isomode pads; method of pad installation and their impact and shock absorbing qualities when used with various types of machinery and testing equipment.

61. Centrifugal Pumps

Quimby Pump Div., H. K. Porter Co.—8-page illustrated bulletin No. 300A describes line of model Q close-coupled centrifugal pumps for general service in capacities of 10 to 1000 gallons per minute. Selection tables, dimensional data and construction features are detailed.

62. Heat Resistant Plastic

Rohm & Haas Co.—4-page illustrated folder "Announcing Plexiglas V" deals with this heat resisting plastic which has excellent moldability and exceptional water white clarity. Shrinkage after 48 hours at 100 C is less than 10 mills per inch. Material is available in commercial quantities.

63. Name Plates

American Name Plate & Mfg. Co.—8-page illustrated catalog shows common and well known name plates of decorative nature, plates bearing legends and diagrams and precision scales and rules. Lettering, design, shape, color, finish and price of plates are covered.

64. Fused Plugs

Electro Motive Mfg. Co.—4-page illustrated folder "El Menco Fused Plug" describes this plug type electrical connector which carries its own fuse. It attaches to cord just as ordinary plug, and blown fuses are removable for replacement.

65. Hydraulic Power Unit

Simplex Engineering Co.—4-page illustrated bulletin PU presents information on Seco Fluid Power Package which is ready for installation on almost any type hydraulic press. Schematic drawing shows complete details of unit.

66. Torque Motors

B. A. Wesche Electric Co.—8-page illustrated bulletin No. 3a/19 presents information on custom built torque motors in any size up to 75 horsepower for any application. Typical motors are shown.

67. Fastening Devices

Lamson & Sessions Co.—24-page illustrated brochure "Lamson Special Purpose Fasteners" reveals information on line of fastening devices which includes nuts, lock nuts, pipe plugs, Lok-Thread studs, plastic inserts, weathertight bolts, bent bolts, wire rope clips, cotter pins, road machinery bolts and nuts, furniture bolts, place bolts, Dardelet River bolts, set screws, etc.

68. Solenoid Valves

Automatic Switch Co.—12-page illustrated catalog No. 200-R reveals information on line of Asco solenoid valves for automatic and remote control of the flow of liquids and gases. All units operate on standard 110, 220 or 440-volt 25/30/50/60-cycle alternating current or 115 or 230-volt direct current. Pilot and explosion-proof valves are covered also.

69. Pneumatic Equipment

Hansen Mfg. Co.—4-page illustrated catalog "Airline Equipment" deals with complete line of sockets, plugs and hose clamps for air, oil, grease, oxygen and acetylene; union stems; pipe unions; air blow guns; spray guns; engine cleaners; and sandblast cleaners.

70. Electric Motors

Eicor, Inc.—Illustrated data sheet No. 47-1 describes model No. 7 alternating current motors which are available in ½, ¾ and 1 horsepower ratings. Diagrams on performance and torque values are included.

71. Voltage Controls

Superior Electric Co.—12-page illustrated bulletin No. 547 covers various types of voltage controls including Powerstat variable transformers and Stabiline voltage regulators and outlines their connections, adaptations and ratings. Both electromechanical and instantaneous electronic models are portrayed.

72. Hydraulic Power Units

B. F. Perkins & Son, Inc.—8-page illustrated folder "Perkins Hydraulic Power Units" deals with models 200 and 375 low pressure; 275, 220, 8200 high pressure; and type L dual pressure series hydraulic power units.

73. Pillow Blocks

Randall Graphite Products Corp.—20-page illustrated catalog No. 47 outlines features of self-aligning, self-lubricating pillow blocks which feature multiple mounting facilities, lightness of weight and cadmium finish.

74. Hydraulic Press

Denison Engineering Co.—8-page illustrated catalog HydrOILic Press", Vol. 1 No. 1, presents photographic reproductions, charts, tables and specific information regarding application of hydraulic press.

75. Bonded Rubber Mountings

Lord Mfg. Co.—10-page illustrated bulletin No. 106 presents features of Multiplane shear type bonded rubber mountings for isolating vibration from all directions. Standard sizes, specifications and dimensions are given.

76. Snap Action Switch

Mu-Switch Corp.—4-page illustrated folder No. Q-1-547 outlines features of model Q miniature snap action precision switch for application in industrial, transportation and communication fields. Unit has high current carrying capacity and an approximate life of 50,000 operations. It is less than ¾-inch in diameter.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below.

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78. Relays

American Relay & Controls, Inc.—4-page illustrated folder "Amercon Relays" describes twelve different types of relays of various ratings for practically every type of equipment control. Included in discussions are leaf switches, snap switches, etc.

79. Small Transmissions

Oilgear Co.—8-page illustrated bulletin No. 67110 describes line of small fluid power variable speed transmissions up to 3 horsepower in size. Input speeds up to 1750 revolutions per minute can be accommodated and output speeds are variable from 0 to 1600 revolutions per minute.

80. Hydraulic Cylinders

Air & Hydraulic Div., Lindberg Engineering Co.—12-page illustrated bulletin No. 700 describes oil hydraulic cylinders available in ten standard bore sizes of from 2 to 8 inches and in seven selective mounting styles for practically any type of installation.

81. Speed Reducers

Ottumwa Iron Works — 4-page illustrated folder form No. 102 presents features of fully enclosed, automatically lubricated, dustproof and oiltight single, double, and triple reduction types of speed reducers. Service factors, capacities and ratios are charted.

82. Optical Comparator Charts

Engineers' Specialties Div., Universal Engraving & Colorplate Co.—60-page illustrated spiral-bound booklet is compilation of several bulletins and data sheets describing radius charts, projector charts, projector scales and projector rules for use on all makes of optical comparators and measuring and micro projectors.

83. Bolts, Nuts & Studs

Pawtucket Mfg. Co.—54-page catalog No. 46 is intended to serve as guide in selecting brass, bronze, silicon bronze, stainless steel and Monel metal bolts, nuts, washers and screws. Catalog provides specific information and price listings on wide variety of types and sizes.

84. Tube Fabricating Equipment

Parker Appliance Co.—12-page illustrated catalog No. 401 outlines features of production tube bender and accessories, hand benders, cutters, flaring tools, beading kit and tube fabricating service. Helpful operating information and photos illustrating tools in use are included.

85. Infrared Lamps

General Electric Co.—6-page illustrated folder Y-689 contains descriptions and technical data on industrial heat lamps for use in heating, drying and baking applications. Also described are four types of ovens suited for employing these lamps.

86. Industrial Adhesives

B. B. Chemical Co.—4-page illustrated folder "Adhesive Facts" describes line of air drying cements, cold curing cements, hot curing adhesives and dispersions for joining plastics to metal, wood, cloth, leather, rubber or any combination of these materials.

87. Hydraulic Pump

Pesco Products Co.—Illustrated data sheet No. 109 deals with model No. 051006-010 all-purpose hydraulic pump designed for use on dump trucks, lift trucks, industrial trucks, hydraulic presses, machine tools, stackers, loaders, etc. Capacity is 15 gallon per minute at 1200 revolutions per minute at 1000 pounds per square inch.

88. Small Induction Motors

Jack & Heintz Precision Industries, Inc.—4-page illustrated folder presents information on type C fractional horsepower induction motors which provide constant speed. Standard rotation is counter clockwise. Diagrams of construction and outline dimensions are included.

89. Induction Heating Gun

Ohio Crankshaft Co.—Illustrated data sheet "The Tocco Heat Gun" describes portable induction heating gun and relates its features. Unit is recommended for induction soldering, hardening, brazing, annealing, melting and forging operations. Gun is fully portable.

90. Bearings

Bunting Brass & Bronze Co.—64-page catalog No. 46 deals with industrial, precision bronze, electric motor, graphite oilless bearings and babbitt metals. Data on standard stock sizes, prices and specifications are included as well as inside and outside diameters, lengths, flanges, etc.

91. Variable Speed Drives

American Pulley Co.—Illustrated bulletin "Speed-Jack Drives" explains how maximum and minimum speeds on machinery drives operating up to 1 horsepower can be obtained through use of variable speed transmissions. Drive tables and charts enable user to select quickly proper size sheaves for desired speed range.

92. Stainless Steel Tubing

Babcock & Wilcox Tube Co.—4-page illustrater folder "B & W Stainless Steel Tubing" presents line of tubing for application in process piping, evaporating and condensing equipment, heat exchangers, precoolers, transfer lines and other related uses. Grades, sizes and finishes are covered.

93. Milling Machine Attachment

Malnar Machine & Tool Co.—Illustrated data sheet "Make Your Bridgeport Universal" describes horizontal unit for milling machine that eliminates need of resetting errors, provides spindle speeds from 125 to 3000 revolutions per minute and permits accuracy and high production rate. Unit is shipped ready for installation.

94. Strip Expanders

H P L Mfg. Co.—4-page illustrated folder "New Strip Expanders" describes units that are designed for use on all pneumatic or hydraulic equipment to maintain constant contact between packing seal lip and cylinder wall. It is necessary only to cut suitable length of expander and insert it between seal and plate to secure required pressure on lip.

95. Metal Strengthening

Rigid-Tex Corp.—12-page illustrated bulletin No. 447 describes Rigidizing process for strengthening and decorating ferrous or nonferrous strip and sheet metals. Information on range of applications, cost reduction through use of Rigidized metals and patterns obtained are presented.

96. Flexible Couplings

Climax Flexible Coupling Co.—4-page folder form No. 51-SE deals with types A, SA and L knob disk constructed flexible couplings. These units provide noiseless operation and complete insulation between driving and driven units. Information on how to select proper coupling is given.

97. Springs

H. K. Porter Co.—28-page illustrated catalog "Porter Springs" covers wide range of half and full elliptic springs, truck springs, bolster spring plates, helical springs and special wire shapes. Standard tolerance chart, graphs used for hot wound springs and tables for cold wound helical springs are included.

98. Mixing Control

Askania Regulator Co.—16-page illustrated bulletin No. 101 deals with equipment for the continuous mixing of two or more fluids in definite proportion. Automatic and manual controls are described and charts are presented to define clearly factors for orifice determinations and ranges of application.

99. Steam Turbine Governor

General Electric Co.—4-page illustrated bulletin No. GEA-4764 describes an electrically governed steam turbine. Governor provides accurate control over wide speed range. Salient features of unit are revealed in cutaway photographs, and schematic diagram illustrates interrelationship of speed sensitive element, control panel and relaying mechanism.

100. Capacitors

Capacitron Co.—Two illustrated catalogs "Type EC Capacitron" and "Motor Starting Capacitors" reveal information on oil type capacitors with ratings up to 10 microfarads at 600 working voltage direct current and line of universal replacement capacitors for alternating current motor starting respectively.

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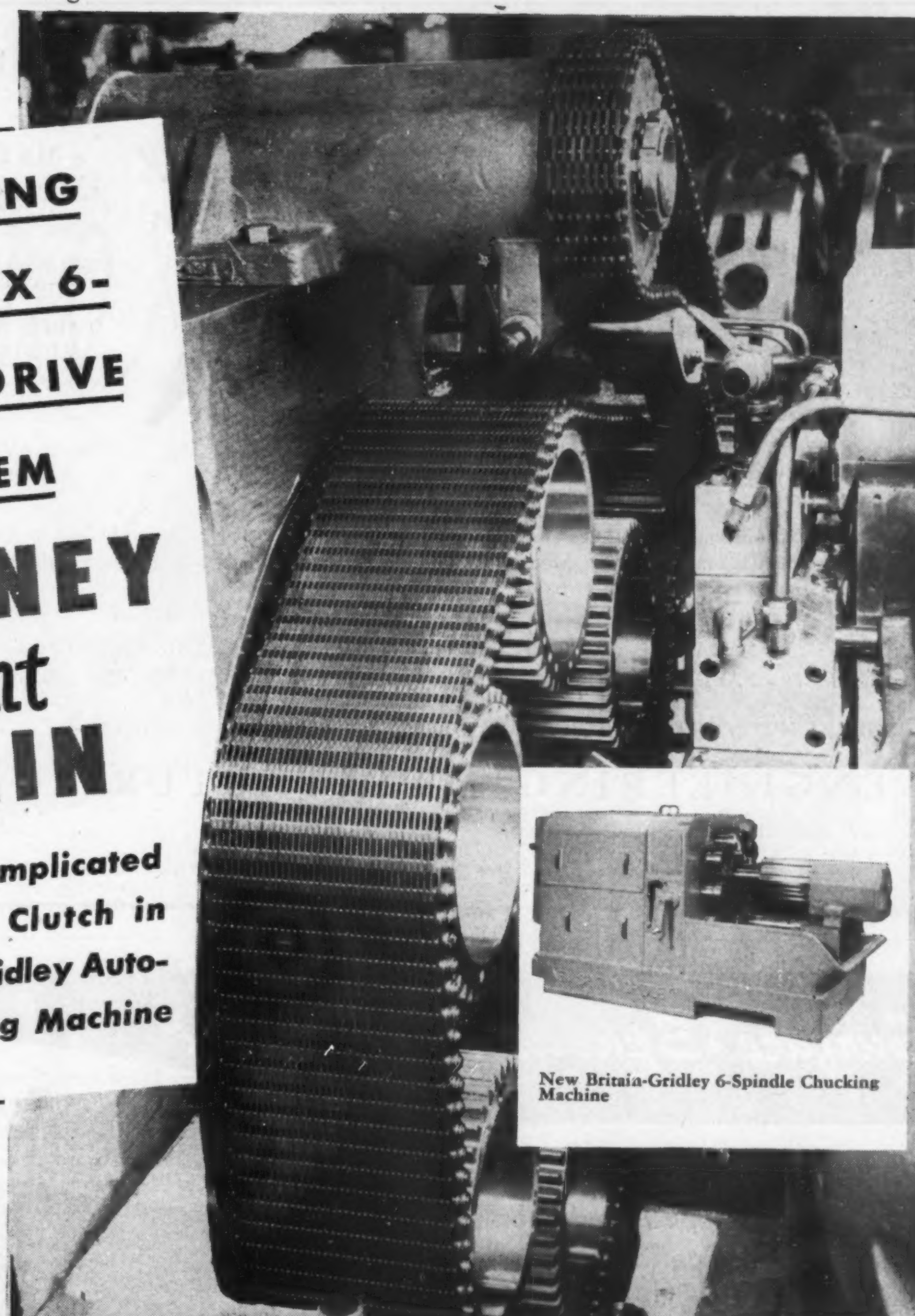
SIMPLIFYING A COMPLEX 6-SPINDLE DRIVE PROBLEM

WHITNEY Silent CHAIN

Eliminates Complicated Gearing and Clutch in New Britain-Gridley Automatic Chucking Machine



Whitney Silent Chain power drive and 6-spindle drive

New Britain-Gridley 6-Spindle Chucking Machine

For positive, uniform spindle speeds, New Britain-Gridley uses Whitney Silent Chain to drive the six spindles in their Model 16 Chucking Machine.

The spindles of this machine are mounted on a circular spindle carrier. Whitney Silent Chain operates on the sprocket portion of the spindles and meshes with each of the spindle drive sprockets. As the spindle carrier indexes, each spindle coming into the loading and unloading station disengages with the chain so the operator may chuck and unchuck the work piece.

After the piece is chucked, the carrier indexes the spindle into #2 position, the sprocket meshes with the continuously operating chain and the spindle begins to drive.

In addition to other advantages, this chain drive design made it possible for New Britain-Gridley engineers to eliminate the need for a clutch to stop the spindle as it indexes into the loading and unloading station.

Designers and builders can improve the performance of their machine tools and other equipment with Whitney chain and cut tooth sprockets. This *all-steel drive* delivers full rated machine capacity, withstands shocks and overloads and cuts maintenance costs. It pays to standardize on Whitney. Write for information, today.

The Whitney Chain & Manufacturing Company

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WOOD BASE TABLE

5-PLY BASSWOOD TOP

STURDY OAK LEGS

ADJUSTABLE TO HEIGHT

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ATTRACTIVELY FINISHED

NOW AVAILABLE WITH KNOB ADJUSTMENT

METAL BASE TABLE

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TABLE STANDS FIRM AND RIGID

SIMPLE AND EASY TO ASSEMBLE

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Man size Knobs make adjustment to height a simple matter. Wood table can be had in Top sizes 21 x 26 through 42" x 72". Metal Base table sizes are from 21 x 26 through 30" x 42". Attached parallel ruling straightedges standard in "C" combinations.

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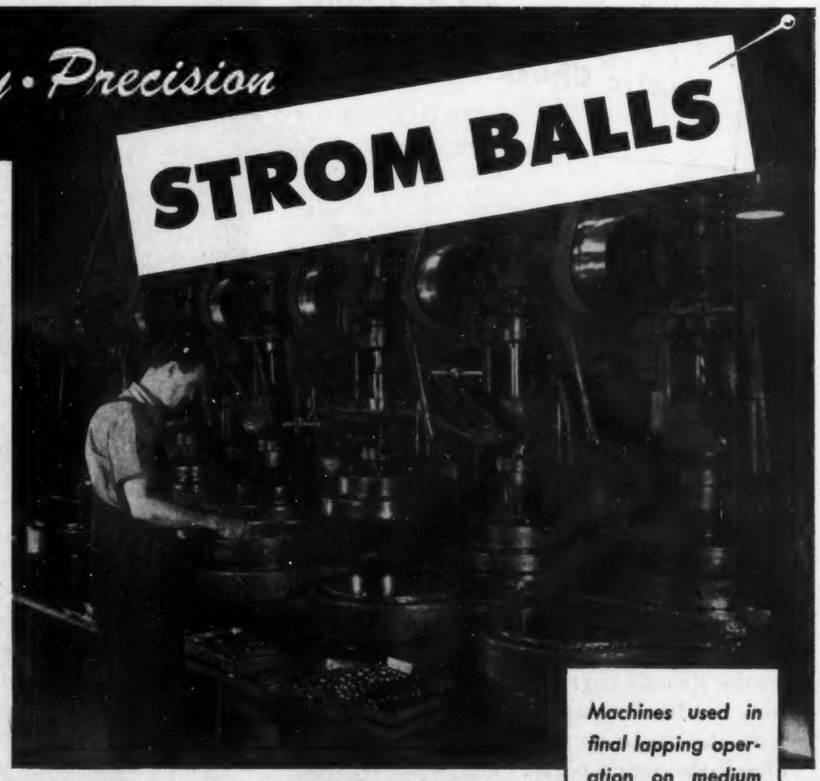

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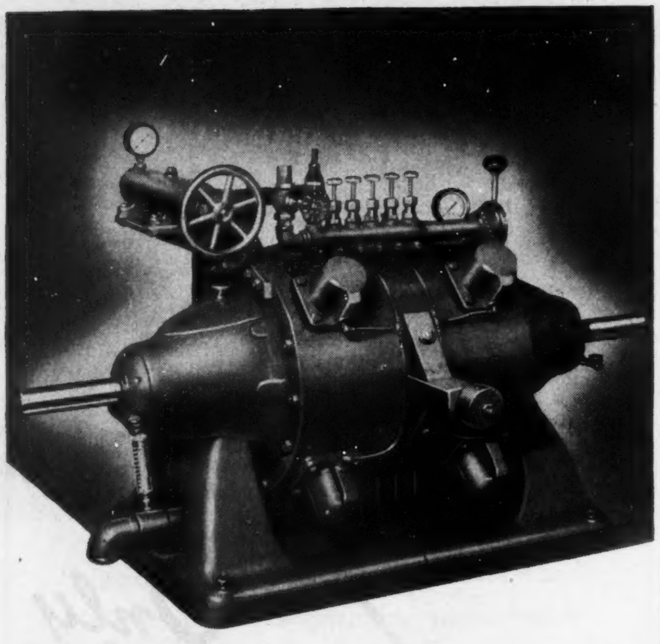

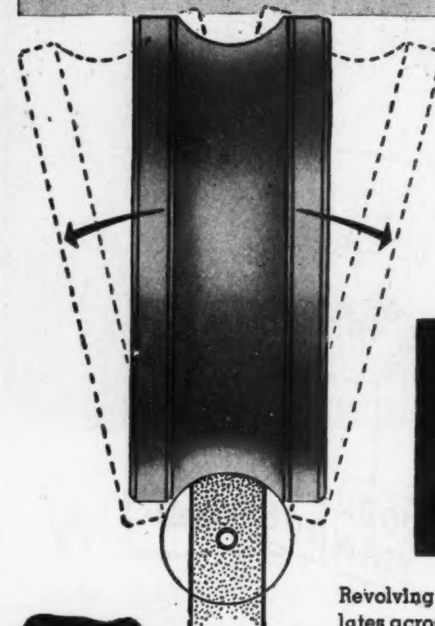

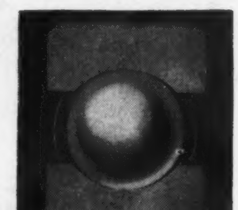

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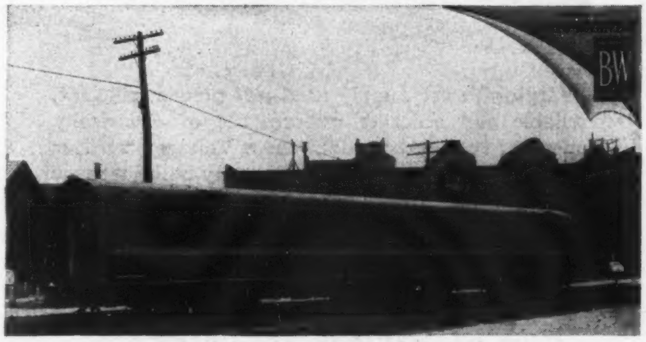

The MECHANICS complete line of Universal Joints ranges from one with $1\frac{5}{8}$ inches swing diameter, weighing less than $\frac{1}{2}$ pound and capable of transmitting 200 foot pounds torque . . .

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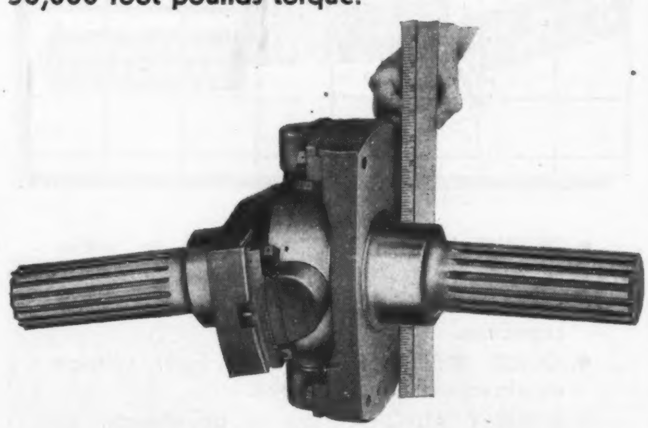

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Connections made through Fanning Strip on bench or anywhere apart from barrier strip, and quickly slipped into assembly.

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JONES FANNING STRIP

Designed for use with JONES BARRIER TERMINAL STRIPS No. 141 and No. 142, for one to twenty terminals.

- Simplifies and facilitates soldering. No complications.
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Send for complete data on this new basic improvement

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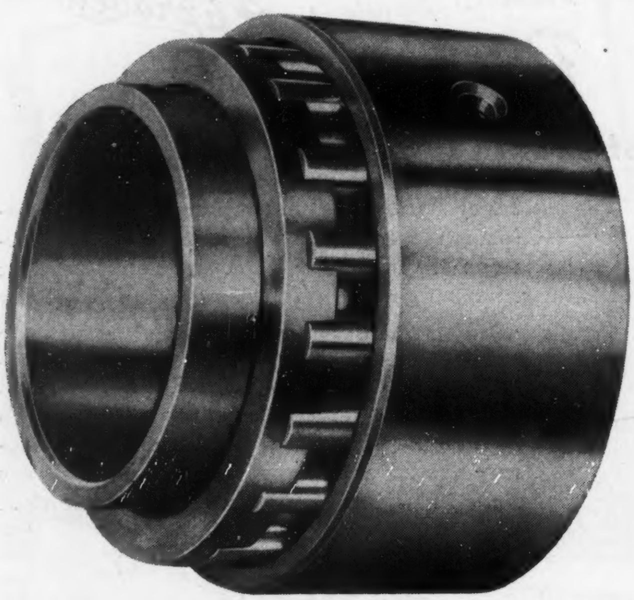
"Extra" Heavy-Duty
Roller Bearings

for the toughest anti-Friction jobs



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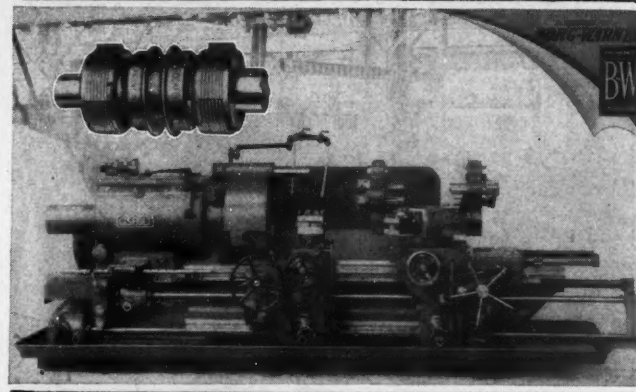

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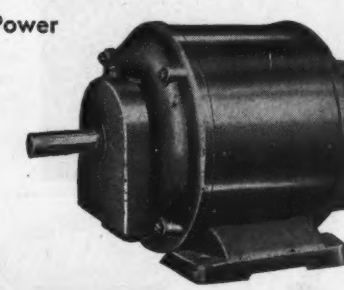

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TRU-LAY PUSH-PULL is made in five sizes. Rated input capacities range from 30 to 1000 pounds. In most cases, terminals and fittings are designed for the individual application.

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Priced at a NEW LOW! Solve price and assembly problems with the 292 Pointer Knob, available now in several variations . . . in large quantities . . . priced right. It's the leader in a full line of standard plastic knobs and control balls for electrical, electronic and industrial use.

Put your plastic knob and control problems up to the largest producer in the industry—Kurz-Kasch. Write for illustrated Catalog 103-A which lists specifications and descriptions of the whole Kurz-Kasch standard line.

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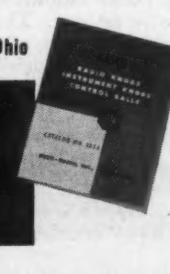

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New KINNEY HIGH SPEED Clutch

Rugged Compact Reliable

Capacity per 100 r.p.m., enclosed Model 1 to 10 H.P.; open construction 6 to 30 H.P.

Exploded view.

This new enclosed type clutch . . . the last word in power transmission . . .was developed by Kinney for driving military equipment under the most difficult combat conditions. Practically indestructible and easily adjusted without special tools, this Kinney clutch is efficient over an unusually wide range of operating speeds.

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1. Special Velvetouch friction surfaces of sintered bronze running against steel discs.

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3. Single point adjustment at threaded case front.

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Product and design engineers can look to WITTEK to help solve their hose connection problems. Wittek Hose Clamps, for over a quarter century known as standard equipment in the automotive and aviation industries, are today widely used on machines, engines and equipment requiring leakproof hose connections for air, oil, gas and water lines. Consult us on your hose clamping problems. Write for Literature.

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A Compact Answer to Your High Pressure Needs

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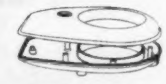
Solves Another Problem

The Commando Aerosol Gun, made by Mayfair Industries, Inc., Chicago, produces a vapor of very fine insecticide particles by means of heat vaporization. The new principle of dispersion makes necessary radical changes in the present conception of mode of action and methods of application of insecticides. The Commando Aerosol Gun is widely used by commercial and industrial companies to control insect pests.

PROBLEM — To join the plastic back plate to the plastic body of the Commando Aerosol Gun in order to hold highly penetrating Aerosol Insecticide and to withstand several pounds air pressure.

SOLUTION — Back plate was joined to body of gun by Reliable bonding using a proper synthetic material as a bonding element.



Bonded Synthetic 2-piece Cast Aluminum Gas Tank

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2-piece bonded micarta Gear Blank

Bonded Synthetic Compression Spring

Bonded Synthetic Flexible Coupling

Reliable makes a specialty of solving just such problems with a bonding technique that permits new freedom of design and fabrication. Synthetic bonding of metal to metal, metal to another material, or one material to another, is often the answer to improved quality and lower costs.

How could bonding with synthetic materials help you? A Reliable engineer will be glad to discuss details with you.

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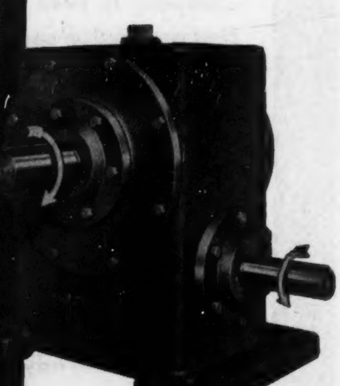
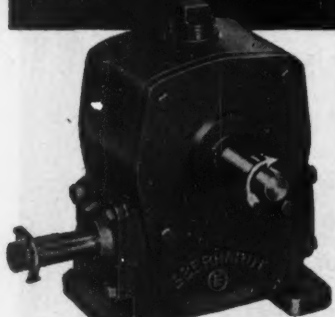
2815-21 IRVING PARK ROAD CHICAGO 18, ILLINOIS

Speed Reducers FROM STOCK





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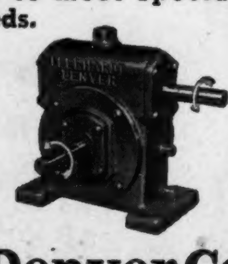

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To control speed of **lift trucks, hydraulic motors, actuating cylinders.**

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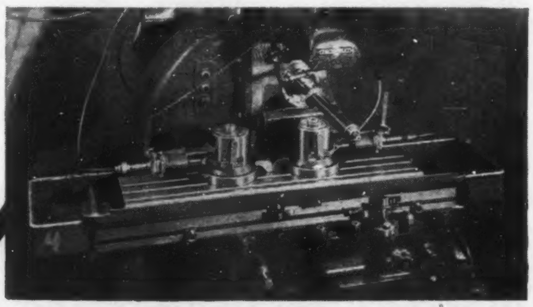

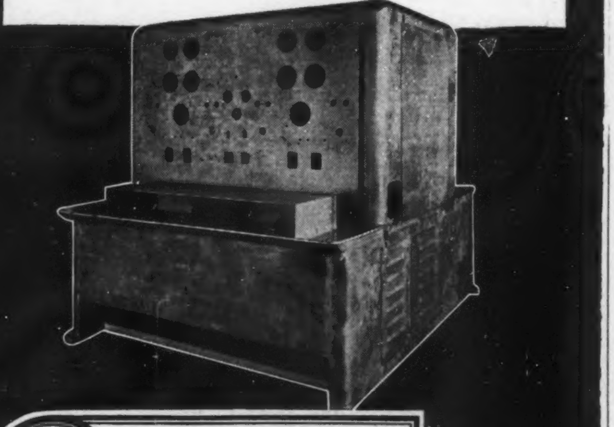

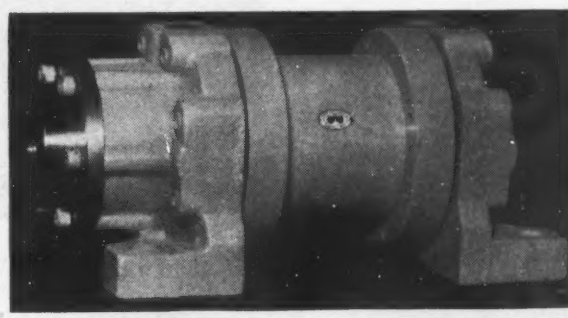

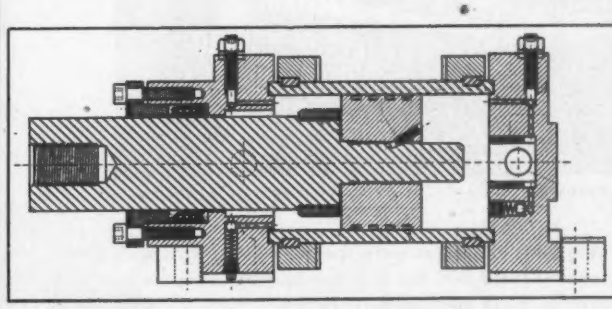

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Are you manufacturing such machines as patch rollers, small pumping, welding or air compressor units? You will find the ideal power unit for your product in the complete WITTE Diesel line.

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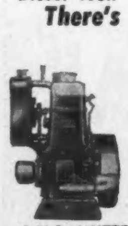

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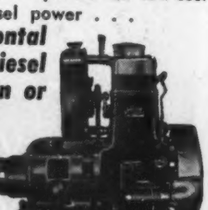

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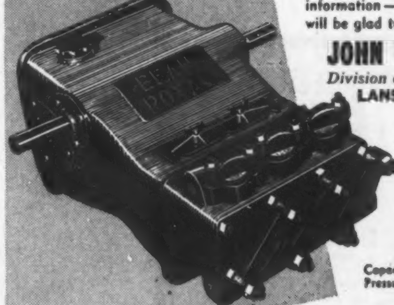

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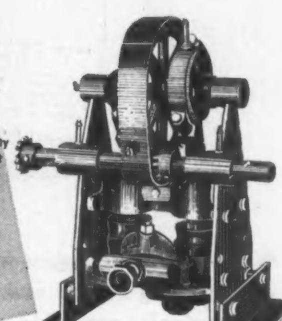

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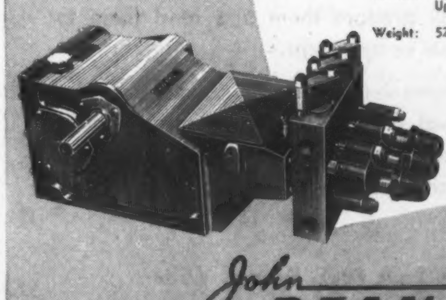

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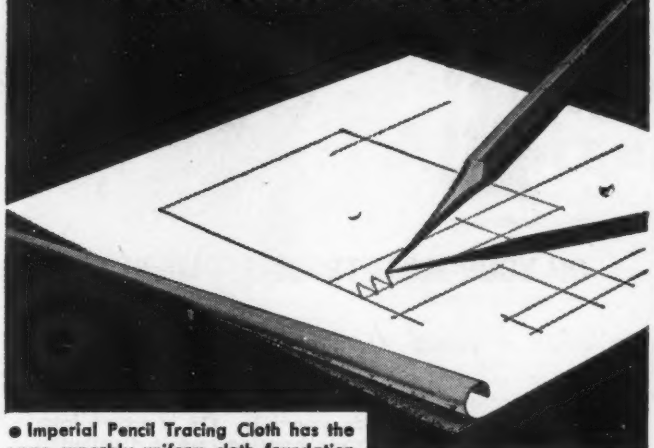
TRACING CLOTH FOR HARD PENCILS



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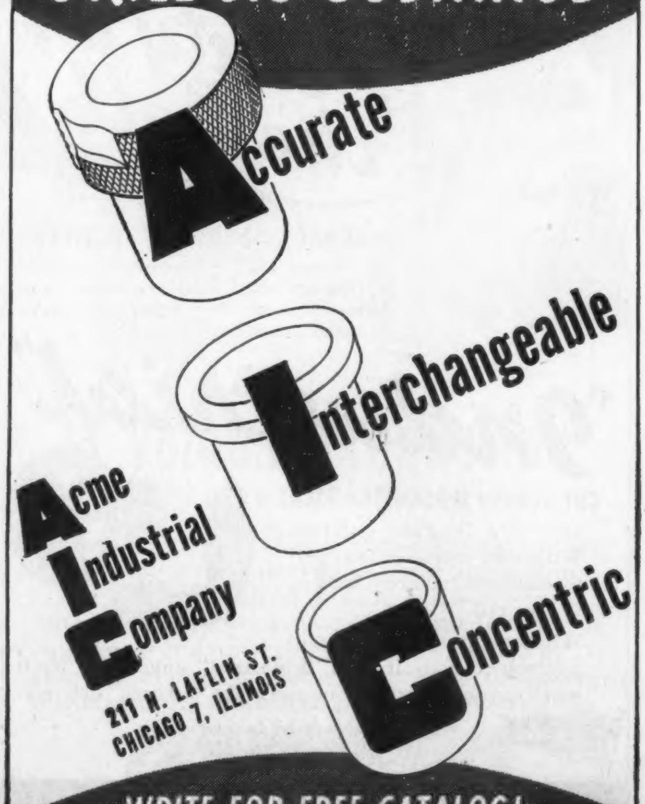

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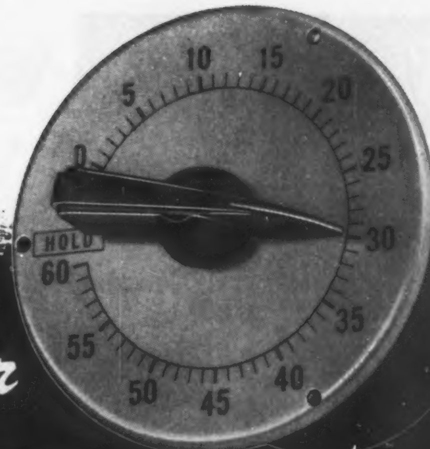
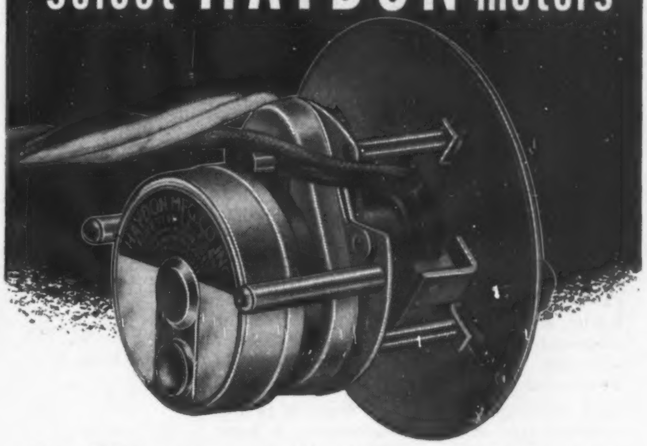


For

TROUBLE-FREE TIMING

select HAYDON motors



The "quick charge" battery charger is but one of the many practical and successful applications for Haydon timing motors . . . providing trouble-free performance, greater operating efficiency and accuracy. The pointer knob is manually set to the starting point — motor and charging unit are energized. When pointer reaches zero on the dial the motor is deenergized and the battery charging unit circuit is closed. Write for details on this and other industrial applications for Haydon timing motors. Free catalog and name of nearest representative on request.

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HARNESS TIME TO YOUR PRODUCTS

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WANTED: Chief tool and die engineer. Manufacturer of bus bodies and custom auto bodies, employing approximately 1100 people requires the services of a qualified tool and die engineer to take complete charge of tool and die engineering and construction of same. Must be experienced in passenger car or bus body tooling, also experience helpful in tooling for plane manufacture. This is a permanent position with a reliable old company. Future for man with proper experience and who can accept responsibility, supervise personnel, and carry complete tooling program. State past ten years of employment giving names of such employers and salary desired. All communications will be held confidential. Address Box 562, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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WANTED: Exceptional opening for sales engineer to cover Mid-West metalworking industry. Selling experience desirable but not essential. Nationally known manufacturer of production material wants man to advise customers on applications—not take orders—working in Michigan and Indiana, with headquarters preferably in Detroit area. Salary to be commensurate with experience. Requirements: Varied knowledge of metalworking production gained by plant work or selling; ability to travel extensively away from home. Write in detail about background. Interview arranged at New York headquarters expenses paid. Address Box 553, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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WANTED: Outstanding technical men for new field offering unusual opportunities in becoming associated at beginning of a project providing unlimited possibilities in nuclear research and aeronautical engineering. Mechanical or aeronautical engineers experienced in heat transfer, thermodynamics, engine design, aerodynamics, stress analysis, mathematical analysis. Metallurgical and ceramic engineers experienced in powder metallurgy; ceramic bodies and coatings. Please furnish complete information, including small photograph, to Personnel Department, N.E.P.A. Division, Fairchild Engine and Airplane Corporation, P. O. Box 415, Oak Ridge, Tennessee.

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WANTED: Machine and electrical designers. Excellent permanent positions open on design staff of large Eastern Pennsylvania manufacturer of varied products. Experience essential in either layout and design of roll-type mixers and other heavy machinery, or in design and layout of complete factory electrical equipment system. Write full details. Address Box 568, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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AVAILABLE: Outstanding manufacturing management executive. Competent seasoned mechanical engineer, seeking a permanent connection with a live progressive organization. Varied experience includes thorough knowledge and capacity for materials management, maintenance, mass precision production and jobbing work, process planning, tool design, tool making, plant layout, assembly operations, forge shop, stamping and press room, grey iron and malleable foundries. Details and reference furnished on request to responsible parties stating their requirements. Address Box 561, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

ADVERTISING INDEX

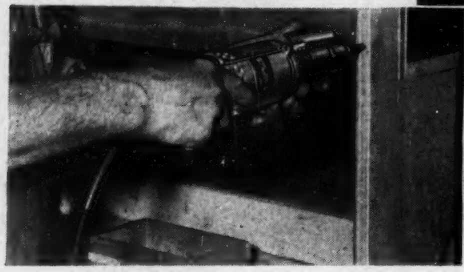
ADVERTISING INDEX

"Phillips Screws Stopped Costly Damage by Slipping Drivers"

says COLUMBUS SHOW CASE CO.

Right — No place for a driver to slip out of a screw head and run wild . . . and it doesn't with Phillips Screws.

Below — With any other type screw than a Phillips, applications like these would require slow, careful, and costly driving.



Excerpts from another of the series of independent surveys by James O. Peck Co. of assembly savings made with Phillips Screws in leading plants.

"In show case assembly," explained the plant manager, "you're dealing with expensive, highly finished materials. That's one big reason we've been using Phillips Recessed Head Screws for over ten years.

"DRIVER SLIPPAGE ELIMINATED 100%. We went to Phillips Screws because we'd had so much driver slippage with slotted screws. A driver jumping out of the slot would often gouge finished wood, so that expensive repairs or an entirely new piece were necessary. Often costly plate glass would be broken. Phillips Recessed Head Screws put a stop to such spoilage completely.

"NO BURRED HEADS HAZARD. Phillips Screws don't burr, so polishing cloths are not snagged, or merchandise such as stockings and underwear damaged. In show cases for food, where moisture is present, this freedom from burring leaves the plating on screw heads intact so that there is no unsightly rusting.

"DRIVING TIME SHORTENED . . . APPEARANCE IMPROVED. The Phillips Recess is so much easier to locate that a "third hand" isn't needed in such operations as fastening together two pieces of wood. You start driving sooner and finish faster. And the attractive Phillips Head adds an extra touch of refinement to the show case design."

Typical of the ultra-modern, beautifully finished show cases in which the Columbus Show Case Company uses thousands of Phillips Screws.

HOW MUCH COULD BETTER ASSEMBLY SAVE YOU? Send for the complete Columbus Show Case report and others, covering wood, metal, plastic products . . . packed with ideas for saving money on your assembly line. Mail the coupon TODAY.

PHILLIPS *Recessed Head* SCREWS

Wood Screws • Machine Screws • Self-tapping Screws • Stove Bolts

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